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HITTITE STELE FROM THE ENVIRONS OF RESTAN AND HITTITE MONUMENTS OF ARSLÂN TÉPÉ.[1]

By P. S. Ronzevalle.

In 1902 M. A. Garcia, engineer, chief of the third section of the line, then under construction, from Rayâk to Hamah, sent me photographs of a monument which he had discovered lying upon the right bank of the Orontes, not far from Restan, the ancient Arethuse. It was easy to recognize here, at a glance, a Hittite monument (Fig. 1). Thanks to the topographical directions which were furnished me by M. Garcia, I found the monument some months later. It is situated about 4 kilometers (2½ miles) down stream from Restan, not far from a barrage of modern abandoned noria, 1 kilometer (0.62 mile) east of the Circassian village of Zahr el 'Asy, which faces it upon the left bank of the river. The right half, longitudinally, of the monument was lacking, but I had the good fortune to take the missing half out of the very bed of the river, where it had served as a barrage.

The stele, of gray local basalt, measures 2 meters in total height (6 feet 6.7 inches) in its present state; the part seen by M. Garcia is 45 centimeters (1 foot 6 inches) wide and the half by me is almost the same; the thickness is 28 centimeters (11 inches). It is complete, except at the top, and naturally, too, but in a very limited degree, along the line of fracture. Various notches, particularly on the reverse of the stele, may be ancient, and indicate, perhaps, that the monument was used in a building; but the matter is very doubtful, for the block certainly does not occupy its original position and appears to me to have been used elsewhere during the Byzantine period. In fact, not far from the river toward the south there stands a small tell dating from that epoch and covering, without doubt, relics of the place inhabited or even founded by the Hittites, fifteen or twenty centuries earlier.[2]

As we see (Figs. 1 and 2), the inscription comprises only two lines of characters in relief, separated by a thin molding. It is of the type of the Hamath inscription reputed to be the most ancient up to the present time;[3]

[1] Translated for Records of the Past from Mélanges de la Faculté Orientale, University of St. Joseph, Beyrouth, Syria, III. part 2, 1909, by Helen M. Wright.

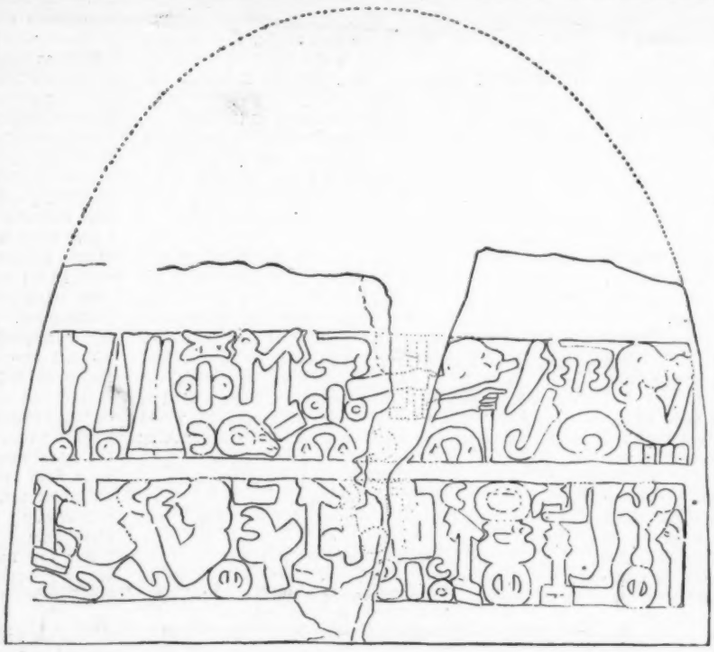


Fig. 3.—RESTORATION OF THE HITTITE STELE INSCRIPTION FROM RESTAN.

[2] It would be very desirable to undertake methodical explorations at that point; the country is deserted, so they would be very easy to carry on, and not expensive, the tell being very small.

[3] Compare in this connection the remarks of Prof. Sayce apropos of the inscription of Kara Dagh, Proceedings of the Society of Biblical Archæology, 1909, p. 83, et seq.

Fig. 1.—NEAR VIEW OF HITTITE INSCRIPTION AT RESTAN.

Fig. 4.—THE TWO PARTS OF THE HITTITE INSCRIPTION AT RESTAN.

Fig. 2.—THE HITTITE STELE AT RESTAN.

Fig. 5. HITTITE RELIEVES FROM ARSLAN TÉPE.

better still, it reproduces a large number of the groups of signs of which the inscriptions of Hamah are composed. It is that which has encouraged me to attempt a restoration (Fig. 3) which I submit to the friendly examination of specialists.

Our stele is, at least with its epigraph, the most southern Hittite stone monument which has been recovered up to date.[4] I believe it contemporary with the stelæ of Hamah; but not having seen the originals I cannot establish conclusive material comparison. If that conjecture were confirmed, the new monument might become the touchstone for deciphering these texts, still obstinate to all consistent interpretation in spite of the firm confidence of Prof. Sayce.

The photographs reproduced in Figs. 5 and 6 were sent to me from Malatia in April, 1907, by a correspondent desiring to know what these curious sculptures represented. Their discovery, he told me in his letter, dated back to January 15th of that year and had been made accidentally upon the little hill of Arslân-tépé, at Orda-Sou, a village situated about an hour north of Malatia. Arslân-tépé, you know, has yielded more than one Hittite piece.[5] These new reliefs are most interesting, and although the photographs which were communicated to me are defective, it seems advisable to me to publish them without further delay. But I regret that our photogravures are so imperfect. In fact, I am obliged to specify, by short description, certain details which have almost disappeared in these reproductions. I may state, moreover, that the stones have been strongly retouched before being photographed; my correspondent informs me, indeed, that in order to show off the sculptures, they had had the unfortunate idea of smearing with black paint the free surfaces of the tablet.

These photographs were taken in the Serail itself of Malatia, where the monuments had been transported and exhibited while awaiting their departure for Constantinople.[6]

The four monuments are authentic in spite of the doubts which assailed them when I described them for the first time to the Academy of Inscriptions and Belles-Lettres. They are in limestone and of varying dimensions; it goes without saying that they are materially independent among themselves, although they were apparently made part of the same construction, temple or palace. That one which bears the god mounted upon a stag is, in its actual state, 82 centimeters high by 45 centimeters wide and 49 centimeters thick (2 feet 8 inches by 1 foot 6 inches by 1 foot 7 inches). The same block bears upon one of its edges a figure of a lion, of which my correspondent has sent me a sketch too imperfect to be published.

Each of these reliefs except the last at the right has its counterparts in the known monuments of Hittite art. The two on the left represent religious scenes. The upper tablet presents to us the figure of a beardless god, made small in order to have all entire on the same block, holding in his right hand a bow and in the other the rein of a stag upon which he is mounted. In front of the god is a beardless figure clothed in a long tunic with fringed border, holding in the right hand a lituus[7] and in the other a vase, the contents of which he pours at the feet of the stag. That figure, apparently a priest, has no head dress; his abundant hair presents the customary large roll. Behind the priest, a small servant, with bare legs and pointed feet, brings to the sacrifice an ibex which he holds by the horns; his hair presents the same characteristic. Above the horns of the stag are four or five hieroglyphs, giving, without doubt, the name of the god; the text continues to the right, in two indistinct groups, which represent, perhaps, the name and rank of the priest.

The second scene is the companion of the first. In place of the priest we have a priestess, whose head is covered with a low head dress, surmounted by a long veil, which hangs down to her feet behind. With her left hand she makes a gesture of invocation, with the other pours a libation in a vase supplied with two handles and a foot and placed on the ground. The divine figure here appears very complex. It is furnished with wings; it is unquestionable, but it is impossible for me to explain certain of the appendages, which, at least at the right, cannot be symbols of writing. The god seems bearded, but that cannot be determined with any certainty. His left hand, held before him, holds an object entirely indistinct; the other, brought back toward the breast, holds a kind of scepter which, according to my correspondent, would have the form of a caduceus of which we see nothing

FIG. 6.—OUTLINE OF BASE OF THE GOD.

but the end. The most interesting detail, perhaps, is the support of the god. Unfortunately, our plate is very imperfect at this point, and I deem it necessary to give a reproduction in outline (Fig. 6).[8] What can be the signification of this curious support? All things considered, I believe that it represents lightning, very much conventionalized, and I propose, pending a more extended examination, to identify it with the support still unexplained of the portable *edicule* of the reliefs of Yazili-Kiaya, an *edicule* which we encounter even in Hittite writing.[9]

The third tablet is very fragmentary; two bearded figures with long rolled tresses, wearing the same costume, one following the other, the first set upon the tops of mountains, represented by little pedestals,[10] The same figure holds with his right hand a club and with the left a staff bossed at its upper end, perhaps a lance. The second figure appears to pierce with his lance an enemy (man or beast) which touches him above the knee. The club which hangs about his elbow is noticeable.

There remains the last fragment, which constitutes for me a veritable enigma. The scrolls of the border[11] can be only a variety of the ornament in spiral or in twist, so frequent in Anatolian art; but what is to be thought of the rest of the sculpture? In whatever direction we turn it, we do not arrive at any conclusions as to the significance of the three objects which seem confined in the meshes abutting on the border.[12] It would be more prudent to wait until the monuments are taken to Constantinople where they may be studied at leisure.

Such as they are, these fragments are important for many reasons. If the date can be proved, at least approximately, the much discussed date of the sculptures of Yazili-Kiaya would be proved, and with it assured chronological data for the history of Hittite art. Besides, the preservation of these reliefs of Arslân-tépé was much better than that of the rock reliefs of Yazili-Kiaya, many details which are distinguished with difficulty upon the latter appear here with clearness. That is true especially of the head dress and of the costume of the four divinities. No doubt if excavations were made at Arslân-tépé, some results very important to all Hittite antiquities would be forthcoming. It is high time to do this. According to my correspondent, many other sculptures than these which I have just described have been obtained from the ruins and have disappeared before the Turkish government could lay hands on them. With the rest of these stones have been discovered also some metal objects, particularly a silver dish. It is probable that the finds would not be very heavy; the tell is not more than 30 meters (98 feet) high and the same in circumference, according to appearances, and it probably covers a temple or palace built upon an artificial elevation.[13]

For the head dress, compare Perrot, IV, p. 645, where it seems better preserved than anywhere else. The same ornamentation in ringlets is seen, besides, in our reliefs from Arslân-tépé, even upon the clubs. That makes me believe that the supposed "caduceus" of the winged god, the end of which we do not see, is likewise a club. For the costume of the same god, I have already referred to Perrot, IV, Yazili-Kiaya, section D. For the others, it is necessary to compare not only the Hittite sculptures, but also the figures from the islands and from Asia which have been preserved for us by the monuments of Egypt. Compare W. M. Müller, *Asien u. Europa* . . . . pp. 337-368. Note an interesting detail; the hooked form of the sword, fixed horizontally at the belt of the two gods one following the other.

[4] I do not know whether it is necessary to take seriously what many have said of the stele of As-Sâlihiyé from Damascus, described first by Porter, Five Years . . . I, p. 384, then refound by Wilson and carried to London by the Palestine Exploration Fund, cf. Quarterly Statements, 1899, pp. 87, 152, and 210. Conder reviewed it in the second edition of his Syrian Stone-lore, p. 463.

[5] Messerschmidt, Corpus inscript. hettitic, p. 13; cf. 2nd Nachtrag (MVAG, 1906, p. 328), p. 7, pl. XLVII, which reproduces the bas-relief in basalt in the Louvre (Heuzey, Les origines orientals de l'Art, pl. X). My correspondent recalls having seen, at the age of 14, the bas-relief of similar style, but in limestone, preserved to-day in Constantinople.

Arslan-tépé (mound or hill of the lion) probably derived its name from a figure of a lion discovered or seen in the ruins; that may be one of the lions of the bas-relief above mentioned, but I would rather believe that the name made allusion to the relief which I shall mention later, in the text and the notes, or to some other sculpture representing some large isolated lion.

[6] The American Expedition from Cornell University found them still at Malatia (cf. Orientalist Literaturzeit, 1908, col. 258, and American Journal of Archæology, 1908, p. 89). According to my correspondent "another stone, very large, has been subsequently transported to the Serail"; it bears a text of which he sent me a copy, too indistinct to be reproduced here. I do not believe it necessary to reproduce further his copy of other texts.

[7] My correspondent, whom I questioned about the unusual termination of the lituus, believes he sees there "a head of a goat, whose eyes only are distinguishable."

[8] My correspondent, whom I asked to describe the support, saw in it "two birds with tails touching each other."

[9] Cf. in the latter case, Sayce, Proceedings of the Society of Biblical Archæology, 1905, pp 23, 27. I wonder whether the support of the two metamorphosed bull genii of Yazili-Kiaya might not be also a conventionalized lightning. Cf. Human and Puchstein, Reisen in Kleinasien . . . p. 56 and pl. IX. Upon the various forms of lightning in oriental art, cf. the original and useful work of P. Jacobstahl, Der Blitz in d. orientalisch. u. griech. Kunst, 1906.

[10] As at Yazili-Kiaya.

[11] The photograph of my correspondent includes only the two rows of the original block; there remains at the right a surface 48 cm. (1 ft. 7 in.) long, where there was no relief. It is, then, clearly a border.

[12] My correspondent sees here animal figures, "of which only the eyes are distinguishable."

[13] After this article went to press, I read the short notice by Prof. Garstang concerning the same monuments in the first part of the Annals of Archæology and Anthropology, Liverpool, pp. 3-4, pl. IV-V. I am very glad that the reproductions of the English savant are better than ours; they will serve in some points as a check on my very long description.

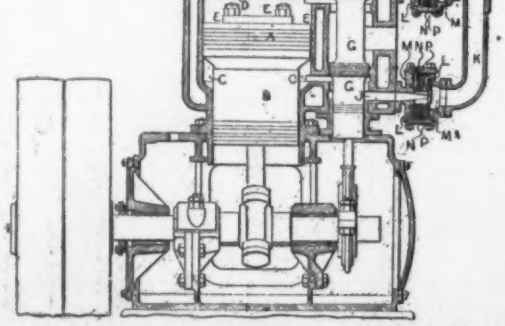
AN IMPROVED SINGLE-STAGE AIR COMPRESSOR.

THE accompanying illustration shows an improved form of single-stage air compressor of the vertical trunk piston type, which has been designed by Mr. S. E. Alley.

It will be seen that the trunk piston, of otherwise usual construction and form, has parts *A B* of two diameters, the greater *A* above and the lesser *B* beneath, thus forming a down-stroke compression chamber *C* between the annular area formed by the reduction of the cylinder to fit the lower smaller piston part *B* and the annular piston area due to the difference in area between the lesser lower piston part *B* and the greater upper piston part *A*; while between the upper surface of the piston part *A*—the piston head—and the cylinder cover *D* is formed the usual up-stroke compression space *E*.

Inlet and discharge of air from the two compression spaces *C E* are controlled by a piston valve *G* between the discharges *H J*, from which and the delivery *K* from the compressor are automatic valves controlling that delivery. These valves consist of thimbles *L* fitted in cylindrical cavities and bearing upon seats in passages formed in valve boxes *M* arranged in the delivery pipes, springs *N* within the thimbles and acting between them and covers *P* on the valve boxes being provided to operate them.

In carrying out this design, the object has been to simplify construction, reduce weight, and to produce a novel, simple, and effective combination of compressing unit and its controlling valve gear.



AN IMPROVED SINGLE-STAGE AIR COMPRESSOR.

It will be seen that such a compressor as this, while essentially single stage, may be looked upon as a unit of one stage in a multiple stage compressor, consisting as a whole of a plurality of such units inter-connected in series.—The Practical Engineer.

The work of Omori, Milne, Denison, and others on the movements of horizontal pendulums due to other than seismic or microseismic causes suggested an investigation of the movements of the pair of Bosch-Omori instruments at the Harvard seismographic station, taking the records for April, May, October, November, December, 1908. Two types of inflection were investigated for each of the components E—W and N—S, and the results appear to suggest a connection with the variations of barometric pressure. The movements of the pendulums show greatest response during the autumn and winter months, and these seasons are those in which barometric maxima and minima are best developed. The possibility of using horizontal pendulums in forecasting on windward coasts has been suggested, and if it can be proved that such indications are given in advance of the barometer, the method may prove valuable.

SIRIUS, THE DOG-STAR.*

"THE KING OF SUNS."

BY ARTHUR R. BARTLETT.

THE study of astronomy has afforded few revelations more wonderful and interesting than those relating to the "king of suns" which, owing to its remarkable brilliancy and superior magnitude, must have attracted the attention of all persons who enjoy an occasional survey of the heavens at this season of the year. From time immemorial this majestic star has been observed with the greatest solicitude by poets, divines and philosophers, and is known to astronomers by the name of Sirius—the famous "Dog-Star" of the ancients. During the winter season it glows upon the evening sky with a luster unequaled by any other star in the firmament, and owing to its location, being situated only about sixteen degrees south of the celestial equator, and nearly midway between the two poles of the heavens, it is visible from every habitable portion of the earth, but in our latitude it may be seen to the best advantage during the latter part of the winter, when it appears toward the south at an early hour in the evening.

Sirius, after it has once been identified and carefully located among the neighboring stars, may be easily recognized at any time during the winter, for owing to its attractive appearance and superior brilliancy, when seen on a clear night by an attentive observer, it will never be forgotten. There is no other star in the heavens that has been more universally observed, and around which there cluster so many ancient associations and superstitions, or has received more attention, both from astronomers and the general public, than this glorious orb. Whoever has looked upon the beautiful star, located in the brightest region of the heavens, and seen it glowing on a clear winter evening, must have beheld with awe and admiration its indescribable splendor; and one need not be an astronomer to admire its radiant glory, or to conclude that this charming orb possesses characteristics distinguishing it from any other star in the firmament. Sirius crosses the meridian about four minutes earlier each evening, and shines with a brilliancy which cannot fail to arouse the interest and curiosity of the most casual observer. But if one watches Sirius when on the horizon, either rising or setting, it will be noticed that it not only changes in appearance, but seems also to blaze forth in different colors, especially on a clear and cold winter evening when the Moon is absent and the stars are observed to "twinkle" more than usual. Sirius appears farther toward the south than any of the bright stars of winter visible in our latitude, being about one-third of the way up to the zenith when at its greatest elevation, and is above the horizon only ten hours out of each twenty-four.

In ancient times, when every man was his own astronomer, the rising and setting of Sirius was watched with great solicitude. The ancient Thebans, who first cultivated astronomy in Egypt, determined the length of the year by its risings, and it was, to a certain extent, the almanac of the ancient Egyptians, who observed its rising with mingled apprehensions of hope and fear. Every year the appearance of this well-known star, just before the rising Sun, was followed by the rising of the River Nile, and thus it was like a faithful watch-dog, giving warning of the approaching overflow of the waters, for which reason it received the name of "Dog-Star." To that season of the year when Sirius rose with the Sun, and seemed to blend its own influence with the heat of that luminary, the ancients gave the name of "dog-days." At that remote period they commenced on the 4th of August, or four days after the summer solstice, and continued forty days, or until the 14th of September. But the rising of Sirius varies with the latitude of the place, and in the same latitude is perceptibly changed, after a course of years, by what is known as the precession of the equinoxes. The modern "dog-days" extend from the 3rd of July to the 11th of August, being one day less than the ancients reckoned, and it will therefore be readily seen that they have no reference whatever to the rising of Sirius with the Sun, which occurs at present about the 12th of August. Sirius is with us overhead in the daytime during the so-called "dog-days," and consequently invisible, and is at night in the lower hemisphere, but is visible and conspicuous to us upon the nocturnal sky all through the winter.

Sirius belongs to the little constellation Canis Major or the Great Dog, a group of thirty-one stars situated just south and east of Orion, and almost universally known from the unrivaled brilliancy of its leading orb, but which otherwise possesses no noteworthy attractions. A line drawn from the star Aldebaran through Bellatrix, toward the southeast, will indicate the position of Sirius, which forms with Procyon and Betelgeuse a large triangle, the sides of which are nearly equal. It is also pointed out by the three stars in the "belt" of Orion, its distance from them being about twenty-five degrees toward the southeast. When observed through a large telescope Sirius presents a charming appearance, and shines with a brilliancy that is startling to the beholder. It is not only the brightest star in the heavens, but is more than three times brighter than an ordinary first-magnitude star, and is believed to be 500 times as bright as a star of the sixth magnitude—the faintest visible to the naked eye.

Owing to the remarkable size and brilliancy of Sirius, it was once naturally regarded as the nearest of the stars, but its distance is in reality so great that it has never been satisfactorily determined. Some reliable authorities, however, assign to Sirius a distance of 100 trillions of miles, which is four times the distance of Alpha Centauri—the nearest star known to astronomers—and a million times the Sun's distance from our Earth. Prof. Chambers, in his recent work, "The Story of the Stars," places Sirius as the fourth in order of distance among those stars experimented upon, whose parallax has been measured for the purpose of ascertaining their distances from us. It is estimated by some astronomers that the brilliancy of Sirius is 300 times greater than that of the Sun, and if we assume that the intrinsic brightness of its surface is the same as the Sun's, the surface of this star must be 300 times larger than that of the Sun, from which it follows that the diameter of Sirius is about eighteen times that of the Sun, and its volume about 2,200 times greater. This splendid star is in reality a globe emitting so enormous a quantity of light and heat, that were it to take the place of our Sun, every creature on this Earth would be consumed by its burning rays.

According to Prof. Newcomb, in his recent book on "The Stars," Sirius is thirty times more luminous than the Sun, and its parallax is 37/100 of a second, which corresponds to a distance of at least fifty-one trillions of miles, or about twice that of the nearest star and over 500,000 times the Sun's distance from us; and if these figures are correct, its light would require over 8½ years to reach the Earth. Different astronomers, after careful investigations, have assigned various values to the size and distance of Sirius, but the latest estimates, based upon the recent determination of its parallax, are accepted as the most reliable results, and are doubtless nearer the actual values than those long regarded as correct and given in our text-books on astronomy until of late. While Sirius was formerly believed to be much farther away, it is one of the stars at present known to be comparatively near to us, and in fact, there are only four other stars in the heavens that are known to be nearer.

By means of the spectroscope it has been found that Sirius is receding from our Earth at the rate of twenty-six miles per second; and yet, even with this almost incredible velocity, the passage of a thousand years will make no perceptible difference in the appearance of this brilliant star, so immense is the distance which separates it from us. Sirius is located in that part of the heavens from which the Sun is receding at the rate of twelve miles per second, and its proper motion is such as to have carried it across the Milky Way in ten thousand years according to Prof. Serviss in a recent article which suggested to Ella Wheeler Wilcox her excellent poem entitled, "When Sirius Crossed the Milky Way;" and there is said to be a tradition that Sirius was seen by the men of the Stone Age on the opposite side of the Galaxy to that on which it is now located. Sirius, on account of its brilliancy and prominence, was regarded by Kant, the celebrated German philosopher, as the central Sun of the universe, but his conclusion, though a grand and natural one, has been shown to be erroneous, and astronomers do not recognize any particular star as the center around which all the other stars revolve. It is believed that remarkable changes have taken place in the color of Sirius since it was first observed by astronomers. Sirius was described by the ancients as a fiery red star. Many years ago it was said to be pure white, but it is now becoming of a decided green color, as a careful observer will readily perceive when this star is visible on a clear winter evening.

Secchi, the eminent Italian astronomer, divided the stars into four types, according to their spectra, and Sirius belongs to the first type, in which it holds a leading position, and which includes the highest conditions of development in the stellar universe. We may justly consider this glorious Sun as the center of a system of revolving worlds, and imagine them as being inhabited by creatures far more advanced in intellectual development than ourselves. Sirius, though the brightest star in the heavens and long known as the "King of Suns," is now believed to be exceeded in actual size by Canopus, Antares, Rigel, Spica and Arcturus, the latter probably being at least a thousand times more luminous than our Sun, but all these stars are much farther away, less prominent, and do not possess the interest or importance attached to the "Dog-Star" from the earliest ages. We receive from Sirius only one seven-billionth of the light that the Sun gives us, but the star in reality gives out about forty times as much light as the Sun. It is a very gaseous and expanded body, however, and though very much larger and more brilliant than the Sun, is comparatively light in weight, its mass exceeding that of the Sun only about twenty times.

The late Prof. Proctor, referring to this interesting orb, says: "Sirius shines at least 200 times as brightly as our Sun would shine if set beside it. Assuming its surface to be equally brilliant, this would imply in comparison with our Sun, a diameter fourteen times and a volume 3,000 times as great. Its luster, however, seems higher than the Sun's, but, even making allowance for that, we must still consider this giant Sun to be at least 1,000 times as large as our own orb. Recent evidence tends to show that its rate of recession from us is diminishing, so that we may expect this to change into a motion of approach. Here is a hint that Sirius is traveling in a mighty orbit, with movements carrying it alternately from and toward us." It is interesting to know that the two concluding sentences of Prof. Proctor's remarks, written many years ago, may well be regarded, in the light of recent developments, as a real prophecy that has been partially fulfilled, inasmuch as the motion of Sirius away from us has not only been diminishing, but the star is now known to be actually gaining upon us and overtaking the Earth and Sun at the rate of ten miles per second, notwithstanding the fact that we are receding from it with great velocity as already mentioned. It now only remains to prove that Sirius is moving in an immense orbit around some unknown center to complete the above prophecy, thereby establishing the accuracy of Prof. Proctor's statements and giving them special significance in their relation to our knowledge concerning this famous celestial object.

One of the most interesting results of the observations directed to this wonderful star was the discovery that it is attended by a revolving companion or satellite, the existence of which had long been suspected by astronomers, and which was finally detected by mere accident. The presence of this object had been revealed by the effect of its attraction upon Sirius, the motion of which varied in such a way as to indicate a powerful disturbing influence in its vicinity. The famous German astronomer, Bessel, about seventy years ago expressed his belief that the periodical variations in the motion of Sirius were produced by the attraction of an invisible companion, revolving around the gigantic star. Several astronomers had calculated the orbit of the attracting body, and its distance from Sirius at various times, and though it was diligently searched for, it continued to elude detection, even by means of the most powerful telescopes. But in February, 1862, the eighteen-inch telescope which was being constructed for the Chicago observatory was pointed to Sirius as a test of its power, when the disturbing companion came suddenly into view at a distance of about ten seconds from the large star, and exactly in the direction which had been predicted for that time. The period of its revolution around Sirius was found to be nearly fifty years, and within a few months of the period calculated by Bessel, long before the telescope had revealed its presence.

When the news of its discovery had spread in every direction, all the great telescopes were pointed to Sirius, and it was found that when its exact position was known, it could be easily detected by skillful observers, even with smaller instruments than the one which first brought it into view, the visibility of this very interesting and difficult object depending almost as much upon the altitude of Sirius and the condition of the atmosphere as upon the power of the telescope employed by observers. In a recent magazine article entitled "To Measure the Heat of a Star," the writer says: "Sirius, the Dog-Star, which has twenty times the mass and sixty-three times the brightness of our

* Popular Astronomy.

Sun, travels with a companion that possesses only one ten-thousandth part of its luminosity. It would seem as if the latter must be a very old and nearly extinguished Sun—far gone in decrepitude, as one might say."

It is a remarkable circumstance that Voltaire, who like Dean Swift in his "Gulliver's Travels," attributed two satellites to the planet Mars long before they were discovered or even suspected by astronomers, should also, in his story of "Micromegas," have imagined and described an immense orb revolving around Sirius, many years before its existence had been revealed by the telescope. The hero of his wonderful story came from this imagined planet, and was described as a giant, more than twenty miles tall, who made a visit to the microscopic inhabitants of our Earth. We find, then, that Sirius is a "double star," the two components being physically connected, and forming what is known as a "binary system," the smaller star revolving around the larger, or both around their common center of gravity. Owing to certain irregularities in the motion of the smaller star, which cannot be explained, some astronomers are of the opinion that Sirius has another disturbing companion, and which may eventually be discovered, either by one of the great telescopes already constructed or the still larger instruments now in contemplation for the near future.

SOME USEFUL KNOTS FOR ENGINEERS.*

THINGS THE ENGINEER SHOULD KNOW ABOUT KNOTS.

BY A. LIVINGSTONE OKE, M. E.

THE knots described in this series of articles have been useful to me in my work in out-of-the-way places. Fig. 1 indicates the meaning of the terms employed.

Fig. 2, Simple or Overhand Knot—This is the simplest of all knots to tie, and may be used as a stop on a rope. A free end is necessary to make it. If

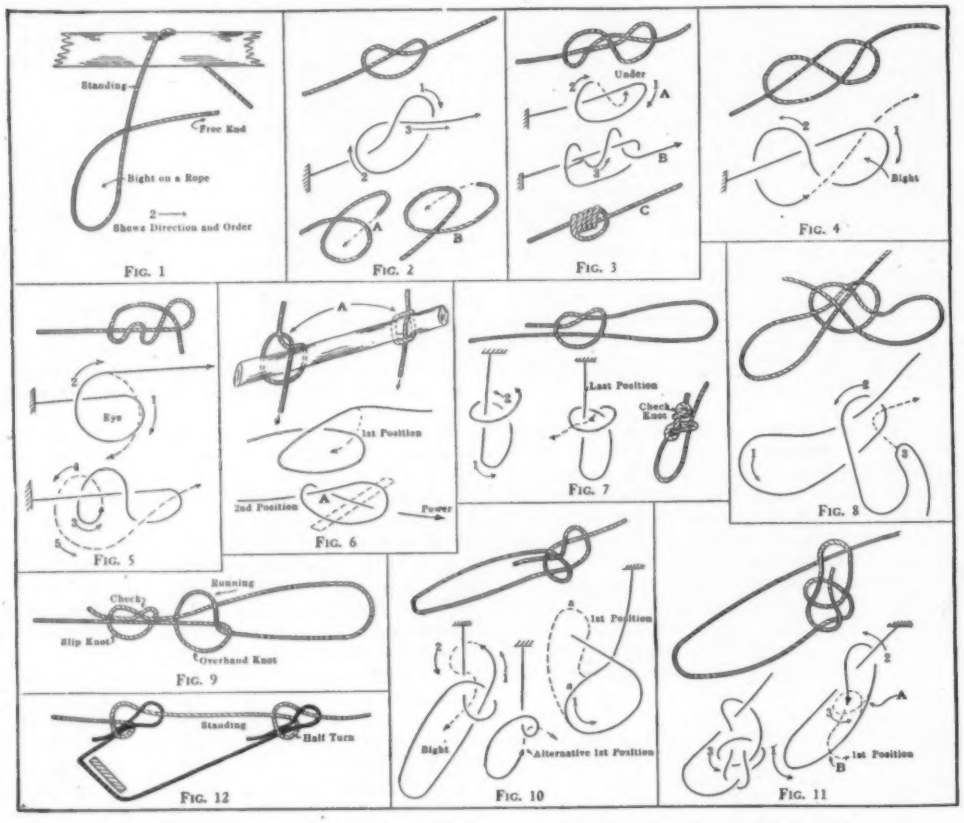


FIG. 1 FIG. 2 FIG. 3 FIG. 4 FIG. 5 FIG. 6 FIG. 7 FIG. 8 FIG. 9 FIG. 12 FIG. 10 FIG. 11

SIMPLE, STOP AND SLIP KNOTS, LADDER HITCH AND BOWLINES.

strained, it injures the fiber of the rope more than a figure-8 knot, and it is difficult to unmake and liable to jam.

Fig 3, Double Overhand Knot—This knot is used for the end of a rope when it is required to prevent its going through an eye, as in a pulley block, or for the end of a halter rope. It is also useful for shortening a rope. It may be made with any number of turns: A in the illustration shows the first position; B, the knot finished with two turns; and C, one with four full turns of rope.

Fig. 4, Figure-8 Knot (Flemish)—This knot may be employed as a stop on a rope; is less injurious to the fiber of the rope, and more easily undone than either the single or double overhand knot. If made with the rope doubled and the bight left long, it becomes a figure-8 hoop knot.

Fig 5, Stevedore Knot—The end of the rope is wrapped twice around the standing and then passed through the eye. It is useful as a stop on a rope to prevent the end going through an eye, as in a pulley block (see double overhand knot). It is also employed instead of sewing the rope end with twine.

Fig. 6, Boat Knot (Marline-spike Hitch)—Suitable for quickly making a rope ladder, or getting a temporary pull on a rope with a marline-spike. No free ends are required to form this knot. The point marked A must always be at the back of the spike or rung of the ladder, away from the direction of the weight or pull.

Fig. 7, Slip Knot (Simple Running Knot)—The simplest kind of slip knot. It may be used similarly to the packer's knot (which will be described in the next series) but is not so good, as it is liable to pull through and does not bind on the rope.

Fig. 8, Tomfool Knot (Double Running Knot)—When the loops are drawn taut and the ends tied, this makes a pair of handcuffs which it is almost impossible for the person so secured to undo. It may be used as a barrel sling, half-hitches being put on the ends, and the hook under the knot itself. The bight marked 3 is passed through the overhand loop as shown by the dotted line.

Fig 9, Flemish Loop—This knot makes a simple loop for light work and may be used in the same way as a bowline, but is not so quickly made; neither is it so secure nor so easily undone. The security depends almost entirely upon the check knot.

Fig. 10, Bowline—A generally useful knot when a loop of any sort that will not slip is required, as in a sling for lowering a man, or fastening a bucket to a rope.

Fig. 11, Running Bowline—As shown in the first position a half turn is made at *A* (shown dotted) and the end passed through and to the back of the part marked B. This is a good slip knot and does not tighten on the standing, always remaining open.

Fig. 12, Bowline II.—A method of attaching the end of one rope to the standing of another. A half turn is put in the standing and the end of the other rope taken through as in tying an ordinary bowline. This knot is practically a sheet bend.

(To be continued.)

* The Engineering and Mining Journal.

American motor car manufacturers are advertising the fact in Canada that the use of automobiles is rapidly increasing among the farmers of the United States, says Commercial Intelligence. Out of 10,000 automobiles in Iowa it is stated 5,000 are owned by farmers. In one Nebraska town of 500 population, 40 automobiles were sold last year to farmers near the town and retired farmers in the town. Careful estimates show that the number of automobiles owned by farmers in the entire United States is 67,000.

THE DECOMPOSITION OF WATER BY THE ULTRA-VIOLET RAYS OF THE SUN.

By DR. KARL STOECKL.

WHEN ultra-violet light, or the rays of radium, fall upon water, they decompose it into hydrogen and hydrogen dioxide. It is worthy of remark that no oxygen is evolved. In this respect the reaction differs essentially from the decomposition of water by electrolysis. The hydrogen and hydrogen dioxide appear to be produced in equivalent quantities. The action of radium rays upon water was investigated first by Ramsay, subsequently by Kernbaum. The quantity of hydrogen produced by ultra-violet rays is not large, even when very powerful sources of radiation, such as the quartz mercury vapor lamp, are employed. Nevertheless, this reaction appears to play a part in the economy of nature, and it may explain many phenomena of the earth and its atmosphere.

Water vapor is present in large quantities in the atmosphere, especially in the lower strata. The ultra-violet rays, which the sun pours forth in profusion, meet this water vapor, and it seems probable that the same reaction that Kernbaum observed in the laboratory takes place in the atmosphere, and that hydrogen and hydrogen dioxide are formed, although in minute quantities. An evidence of the formation of hydrogen dioxide is furnished by the fact that this compound has been detected in freshly fallen rain. The hydrogen, however, being the lightest of all gases, rises and accumulates in the higher strata of the atmosphere. The presence of hydrogen in the upper atmosphere is proved by Pickering's spectroscopic observations of the light emitted by the atmosphere on the passage of meteors at elevations exceeding one hundred miles. The lines of hydrogen were clearly perceived in the observed spectra.

Kernbaum's discovery appears to confirm the theoretical conclusions of several physicists concerning the composition of the atmosphere at great elevations. The Austrian meteorologist Hann has calculated the volume proportions of the constituents of the atmosphere at a height of 100 kilometers, or 62 miles. He concludes that the atmosphere at this elevation contains about 99½ per cent, by volume, of hydrogen, about ½ per cent of helium, and 1-10 per cent of nitrogen, but no oxygen, argon, neon, or carbon dioxide. In other words, hydrogen, which is present only in very minute quantities in the air near the surface of the earth, constitutes almost the whole of the very rare atmosphere found at a height of 62 miles.

Similar results have been recently obtained by the American meteorologist W. I. Humphreys, whose computed values of the percentage composition of the atmosphere at different heights are given in the following table:

Kilometers.	Height in miles.	Nitrogen.	Oxyg'n.	Water vapor.	Carbon dioxide.	Argon.	Helium.	Hydrogen.
150	93	....	....	....	....	.	0.27	99.73
140	87	....	....	....	....	....	0.30	99.70
130	81	0.02	....	....	....	....	0.34	99.64
120	75	0.10	....	....	....	....	0.38	99.52
110	68	0.40	0.02	....	....	....	0.42	99.16
100	62	1.63	0.07	....	....	....	0.46	97.84
50	31	86 16	10.01	....	....	0.08	0.13	3.72
0	0	77.08	20.75	1.20	0.03	0.93	...	0.01

Kernbaum's result also elucidates the theory of the progressive desiccation of the earth, which has long been maintained by some eminent geographers. If part of the water vapor which rises from the earth

into the atmosphere is decomposed by the ultra-violet solar rays, some of the water fails to return to the surface, and the hydrogen which is formed rises into the upper strata of the atmosphere. Hence, in the course of ages, the water which covers the earth's surface must gradually diminish and this desiccation of our planet must have gone on continuously from the earliest geological epochs until the present day.

On the northern slopes of the German mountain ranges the lakes are continually decreasing in size and being replaced by moors. Conspicuous examples are found in the Bavarian plateau. A similar transformation is going on in Switzerland. According to an estimate recently published by Walser, the canton of Zuerich contained 149 lakes 250 years ago, but possesses only 76 lakes at the present time. The dwindling of lakes is also well marked in the lowlands of North Germany, where farms and meadows now occupy large areas which were formerly covered by water. A large part of this transformation is due to deforestation and other causes, but the decomposition of water by ultra-violet radiation may also have played a part. Many of the Russian lakes show a corresponding diminution, and Sven Hedin has described the shrinkage of many lakes and the formation of sandy deserts in Tibet. Similar examples are found in other parts of the world.

What becomes of the hydrogen which thus accumulates in the upper strata of the atmosphere? The physical properties of hydrogen suggest that this lightest of the gases gradually diffuses into interstellar space and becomes forever lost to the earth. —Umschau.

A WIRELESS TELEGRAPH STATION.—I.*

HOW TO CONSTRUCT A 1,000-MILE RECEIVING STATION.

BY EDWARD H. GUILFORD.

THERE are to-day numerous experimenters who desire to own a thoroughly up-to-date and efficient wireless station, but who do not have the means to purchase the necessary equipment ready to install. The author will endeavor to describe in a series of articles the complete construction of such a station, at the same time setting forth the functions of the various instruments. The station, if constructed according to design, should be capable of receiving a 5-kilowatt station, transmitting at a distance of 500 miles, and

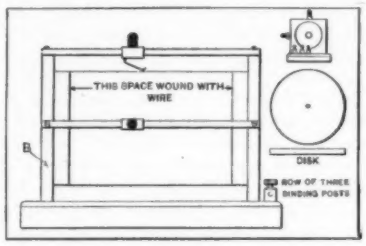


FIG. 1.

to maintain communication over a distance of 50 miles.

I shall begin with instruments of the receiving station, the construction of the tuning coil coming first.

At the present time the tuning coil is used in the modern station merely to "listen in" on, but not to receive messages, as interfering stations cannot be tuned out by it. To tune out all interference either a "doughnut" transformer or an oscillation transformer must be used.

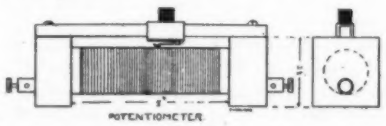


FIG. 2.

The tuning coil, Fig. 1, is a helix of copper wire wound with its turns very close together upon some form, such as a cardboard or wooden cylinder. The wire may be either bare or insulated, but if bare wire is used each turn must be insulated from the neighboring turn on the cylinder. Two movable contacts are used to vary the number of turns of wire used. Perhaps I can make the use of the tuning coil clearer by a short explanation. The length of a Hertzian wave is computed approximately by the following formula (I

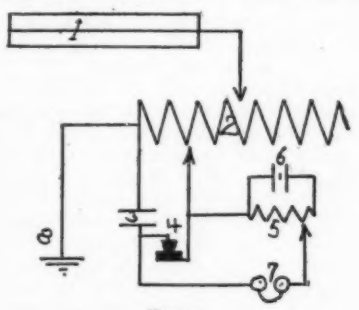


FIG. 3.

say approximately because, to determine the exact length, there are other things to be considered, such as the frequency of vibration):

$$\text{Wave Length} = 2 \times 3.1416 \times 86000 \times \sqrt{L \times C}$$

where L is the amount of inductance in the tuning coil, and C is the amount of capacity in the circuit. Now it will be seen that L and C are the only quantities that can be varied in this equation, consequently, by making either L or C larger or smaller, a long or short wave may be received. Since no two stations send out exactly the same length of wave, some means must be had of adjusting the inductance or capacity

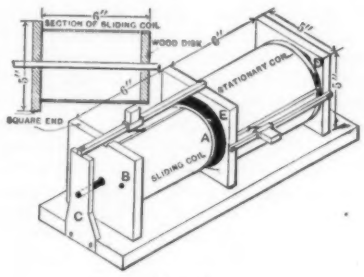


FIG. 4.

of the receiving instruments so that the square root of their product will equal the square root of the product of the inductance and capacity of the sending instruments. Hence the sliders on the tuning coil are used to adjust the inductance, while the capacity is varied

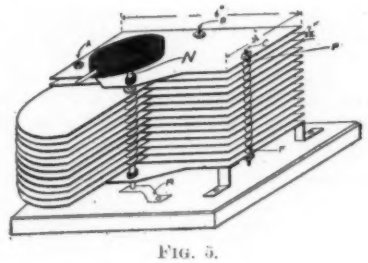


FIG. 5.

by means of adjustable condensers which I will describe later.

I have designed a tuning coil which will receive waves as long as 2,500 meters which will be more than sufficient, since the usual wave length is from 400 to 800 meters.

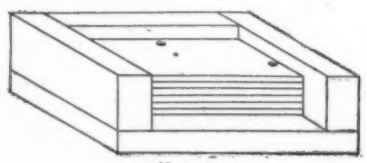
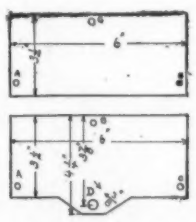


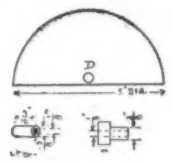
FIG. 6.

The form upon which the wire is wound is made of cardboard of double thickness and cut to such a size that when bent into a cylinder it measures 8 inches in length and 6 inches in diameter with an overlap of 1 inch. The cylinder is formed by wrapping the card-



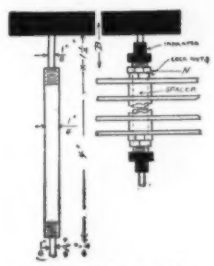
FIGS. 7 AND 8.

board around two wooden disks 6 inches in diameter and ¼ inch thick. (See drawing of tuning coil.) The overlap is then glued together and string is wrapped around the cylinder to hold it in position while drying. The square ends of the tuning coil should be made of mahogany or some similar wood which will finish nicely, although any non-conducting material will do. When the cardboard cylinder is dry the wooden disks should be glued in the ends of it, after boring a ⅛-inch hole in the center of each disk. The cylinder should now be wound with the copper wire. If bare wire is used it can best be done on a screw-cutting lathe, for by means of the screw-cutting attachment each turn of wire can be accurately spaced from its neighbor. If covered wire is used a little frame can be made to hold the cylinder while it is revolved and the wire wound on by hand. In either case while winding, keep the cylinder coated with shellac so that the wire will be firmly held in place. About 150 to 200 feet of wire will be required, the exact length depending upon the distance between each turn of wire. No. 22 B. & S. gage is about the best size.



FIGS. 9, 10, AND 11.

The slider rods (there are two of them) are made from square brass rod 8½ inches long and ¼ inch square. (See drawing of tuning coil.) They are fastened to the ends of the tuning coil by means of a screw through either end. The movable contacts or



FIGS. 12 AND 13.

sliders are made from short pieces of square brass tubing which will easily fit on the slider rods. The contacts are made from spring brass and are soldered to the sliders. It is important that the contact should touch but one wire at a time, so a small dent should be punched in the end of each spring contact in such a manner that it will project down upon the wire.

The tuning coil may now be assembled. Bore a hole in the center of each square wooden end and then by thrusting a ⅛-inch rod through a square end, the

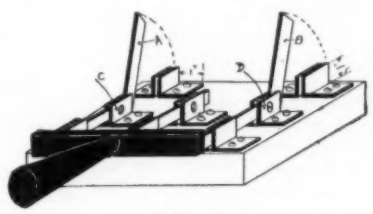


FIG. 14.

cylinder and the other square end, the whole may be held together by screwing a nut on each end of the rod. The slider rods can then be screwed on the square ends, one on top of the coil and one on the side. The coil may now be set on a base similar to the one in the illustration. The three binding posts are connected one to each slider and one to one end of the wire on the coil.

The potentiometer is a resistance used to vary the E.M.F. going through the phones and the detector. It

* Electrician and Mechanic.

is constructed in the same manner as the tuning coil, with the following differences: Only one slider is necessary, and German silver resistance wire is used in place of the copper wire. The cylinder upon which the wire is wound is of wood, 1½ inches in diameter and 5 inches long. A binding post is connected to each end of the wire wound on the coil, and a third binding post is connected to the slider. About 50 to 75 feet of wire will be required. No. 28 single cotton-covered wire is the best. (See Fig. 2.)

The zincite-bornite detector used is the most sensitive known. Its action will be readily understood by referring to wiring diagram, Fig. 3, and normally a small current is flowing from the battery through the detector and telephones. When a signal composed of a series of waves passes from the aerial to the ground through the tuning coil it induces another train of oscillations in the circuit composed of the tuning coil, the condenser, and the detector. Now the detector has the peculiar property of becoming a better conductor when the oscillations pass through it, and so, each time a series of waves pass through it, more current also passes through it, and the signal is thus heard in the telephones. In the recent issues of this magazine there have been several articles on the construction of detectors, so there is no need of going into that detail. Let it be sufficient to say that either article describes an up-to-date form of the detector, and either form will do.

For the interference preventer I recommend the "doughnut" transformer described in the November issue of this magazine, but for the sake of variety I will describe another type of oscillation transformer which is used by a great many operators to shut out interfering stations. Fig 4 shows the type of instrument to which I refer. It consists of two separate cylinders of wire so constructed that one will just slide inside of the other without friction. The inside diameter of the stationary coil is 4 inches, and the outside diameter of the movable coil is 3½ inches. Both cylinders are 4 inches long. The coils are made in the same manner as the tuning coil. No. 22 copper wire is used, either bare or single cotton-covered. The smaller coil slides back and forth upon the rod through its center. This rod runs from the block *C* to the block *D*. The transformer is connected up as follows: Four binding posts are fastened on the base of the instrument, one being wired to each variable contact, one to the end of the wire (wound on the movable coil) at *A*, and one to the wire on the stationary coil at the end *E* of the coil. The wire which connects the end *A* to the binding post should be brought through the inside of the cylinder to the hole *B* and then connected by means of a flexible wire to the binding post.

The action of this transformer is almost the same as the tuning coil. Oscillations passing through the primary coil from the aerial to the ground induce oscillations in the secondary circuit composed of the secondary coil, the condenser and the detector. By varying the coupling, that is, the distance between the secondary and primary coils, very sharp tuning may be obtained.

Probably the most difficult to make of all the receiving instruments is the variable condenser. The condenser consists of a number of fixed metal plates built up in such a way that each plate is separated by a layer of insulating material. A second set of metal plates fastened on an axle are so arranged that they may be rotated and swung in the air spaces between the stationary plates, without, however, touching any of the stationary plates. The maximum effect is obtained when the rotary plates are entirely inside the stationary plates. The electrostatic capacity of a condenser depends upon the area of the metal plates, and the kind and thickness of material between them. Thus by varying the area of the plates exposed to one another and allowing the other quantities to remain the same, the capacity of the instrument is changed. It will be seen that the above action is that which takes place when the movable plates are rotated. The rotary plates are *always* insulated from the stationary plates.

The stock required for both movable and stationary plates is sheet brass about 1/32 inch thick. It will be found that brass of this thickness may be easily cut with the tin shears, while if thinner brass is used it is difficult to keep from bending out of shape. For the condenser sixteen movable and seventeen stationary plates will be required. The stationary plates are easily made, as they are of rectangular shape like Fig. 7. The neatest way of cutting them is by means of a power metal saw, but they may be cut by hand. When seventeen stationary plates (Fig. 7) have been cut a wooden form should be made (Fig. 6) in which to hold the plates while the holes *A*, *B*, *C* (Fig. 7) are drilled. These holes are ¼ inch in diameter. Two plates like Fig. 8 should now be made to serve as bearings for the axle upon which the rotary plates are fastened. This axle is shown in Fig. 12 and in Fig. 5. The holes *A*, *B*, *C* (Fig. 8) should correspond in size and position to the holes *A*, *B*, *C* of Fig. 7. The hole, *D* (Fig. 8) is ⅜ inch in diameter. A number of spacers (Fig. 10) should now be made, by cutting off lengths of brass pipe which has thick walls. It is important that these spacers be all of exactly the same length. The method of assembling the stationary plates is as follows: Take three brass rods *A*, *B*, *C* (Fig. 5) ¼ inch in diameter and 4 inches long, the ends of which have been threaded, and on one end of each place a nut. Then thrust the rods up through the holes of a plate similar to Fig. 8. Now set the rods and plate upon the table and place the remaining stationary plates upon the rods, taking care that each plate is separated by a set of spacers. The remaining plate similar to Fig. 8 is now put on and nuts are then temporarily screwed on the rods. The sixteen rotary plates (Fig. 9) are cut from the same size of stock as the stationary plates. To drill the hole *D* (Fig. 9) the plates should be put in a form built like Fig. 6, but smaller. The diameter of the hole *D* is ¼ inch. The axle (Fig. 12) is made of brass, ¼ inch in diameter. The ends *A* and *B* are turned to ⅛ inch diameter. Fifteen spacers similar to Fig. 10 are made. They should be 3/32 inch long and of such a diameter that they will fit over the largest diameter of the rod, Fig. 12. To assemble the rotary plates, start by screwing two nuts on the end next to *A* of the axle, Fig. 12. Then, after fixing the rod in an upright position place the remaining semicircular plates upon the axle, separating them by spacers. The nuts *N* should then be screwed on the rod so that the plates are fastened firmly together. The plates must be trued up until the straight edges are all parallel. The insulators, Figs. 11 and 13, are turned from hard rubber or fiber. They are intended to fit in the holes *D* of the plate, Fig. 8.

Place the insulators in their position, as shown in Fig. 13, and then set the completed rotary section in the bearing plates. By adjusting the distances *F*, Fig. 5, the bearing plates may be so arranged that the rotary plates will turn in between the stationary plates without touching them. Two binding posts might be set on the base of the completed instrument, one being connected to the spring contact at *M*, Fig. 5, and the other to any of the stationary plates. The handle by which the rotary plates are turned is made of hard rubber, 2 inches in diameter and ½ inch thick. To fasten it to the shaft or axle, bore a 3/16 inch hole half way through the center of the handle and after hammering the end of the shaft square, imbed it in the hole by pouring in hot sealing wax.

The aerial switch is used to change the aerial and ground wires from the receiving instruments to the transmitting instruments. The stock used is ⅛ inch brass about 1 inch wide. The two blades, *A*, *B*, to which the aerial and ground are attached, are cut in the shape of a broad V. The third blade is used to break the primary circuit of the transmitting instruments so that no spark will occur when the operator is receiving. A distance of at least 2 inches should separate each blade. The handle and base are made of hard rubber.

To complete the equipment of the receiving station exclusive of the aerial, a pair of 1,000 ohm telephones with a head band, a buzzer and key (to be used as a tester for the detector), a triple knife double throw switch, an old dry cell, and a double knife single throw switch must be provided.

(To be continued.)

WHAT THE CENSUS BUREAU IS DOING.

A REVIEW OF THE PRESENT STATUS OF ITS NUMEROUS INQUIRIES.

AN idea of the wide scope, as well as of the present status of the various statistical operations of the Census Bureau, may be gained from a report which Census Director Durand has just made to Secretary Nagel, of the Department of Commerce and Labor. This report covers the progress of the great branches of the regular decennial census—population, agriculture, and manufactures—and also the current annual investigations which the Bureau conducts from year to year and certain special investigations in which it has recently been engaged, aside from the decennial census.

Concerning the Population Division, the report states that the work of the 70,000 enumerators has been substantially completed. The schedules containing the population returns have been received from 38,000 districts, or more than half the total number. Some idea of the magnitude of the work of the enumerators, which includes the agricultural census as well as the population, may be gained from the fact that between October 2, 1909, and May 28, last, 32,747,132 schedules, blanks, etc., were sent to supervisors and enumerators, contained in 145,743 packages.

WORK ON POPULATION SCHEDULES.

When the population schedules are received they are subjected to a hand count for the purpose of determining the number of people, on which the pay of the enumerators is in most cases based. They are then subjected to examination with reference to their correctness, especially with respect to mother tongue and occupations. Next they go to the punching machines, where one card is punched for each person; these cards will later be tabulated by electric tabulating machines.

The first of the new-style electric punching machines were received May 2; actual work with them on the returns of 1910 was begun on May 23, and about 75 of the machines are now in operation day and night. There are also about 140 of the old-style plunger punching machines in use. At the present time about 125,000 cards are being punched daily, but it is expected to increase this number shortly to 900,000 cards, and to complete the punching for the entire population by about October 1.

ONE-THIRD OF AGRICULTURAL SCHEDULES RECEIVED.

The Agricultural Division anticipates the receipt of about 6,500,000 farm schedules, besides a large number of irrigation, plantation, florist, and nursery schedules, as well as about 2,000,000 schedules covering live stock in cities and villages, not on farms. Fully one-third of the schedules of each kind have already been received and are in the hands of the clerks for examination and tabulation. The schedules are first classified according to the color of the farmer, the tenure, and the size of the farm, and are then tabulated by means of various kinds of adding machines. About 200 adding machines will be used in this work.

The Agricultural Division also has charge of the annual statistics of cities. The returns for the fiscal year 1908-9 have been tabulated and are about to go to the printer. Twenty men are in the field collecting similar statistics for the year 1909-10.

Relative to the Division of Manufactures, the report shows that about 1,200 special agents have been put in the field for the collection of statistics of manufactures, in addition to 78 clerks detailed from the Washington office for the same work. The work of collecting these statistics in the District of Columbia and Delaware is entirely completed, in Maryland it is practically completed, and in other parts of the country it is about two-thirds completed. The preliminary report on manufactures for the District of Columbia has been given to the press.

The Division of Mines and Quarries, which is a branch of the Manufactures Division, has made substantially similar progress in the field canvas.

THE SPECIAL CENSUS REPORTS.

The Division of Manufactures took a census of electric industries covering the year 1907, a continuation of a quinquennial series begun in 1902. Those parts of the report which deal with telegraphs and with street and electric railways have been issued, and those dealing with electric light and power stations and telephones are almost ready to issue from the press.

The Division of Manufactures conducts an annual inquiry regarding the production of lumber and other forest products. Returns have been received from 57,000 of the 85,000 establishments to which cards were sent regarding the business of the year 1909. The annual work of collecting statistics of cotton ginning, which also falls to the Division of Manufactures, has been completed for the crop year 1909, and the report has just been issued, entitled "Cotton Production. 1909." A revised list of ginneries has been prepared for the next canvass, and contracts with special agents for collecting the statistics are now being entered into. These agents are paid on a piece-price basis.

The Division of Vital Statistics, which collects annual statistics of births and deaths, reports that the tabulation of the mortality statistics for 1909 is well under way and is expected to end by July 20. From January 1 to May 31 the reports of 160,280 deaths occurring during 1910 were received by this division. It is preparing to issue its first report on birth statistics, covering the year 1908, the tabulation for which is nearly completed.

OTHER OFFICE DETAILS.

The Division of Revision and Results, which reviews the manuscripts prepared by the other divisions and assists in planning methods of tabulation, has also direct charge of the statistics of the population of institutions, such as prisons, insane asylums, and the like. More than 3,500 agents, mostly employees of the institutions concerned, are furnishing monthly returns covering the year 1910.

The personnel and expense of the Census Bureau have naturally grown rapidly with the new work of the decennial census. The Bureau had 761 clerks in the Washington office on December 1, 1909, and 1,908 clerks on June 1, 1910, the number increasing since then at the rate of about 50 per day.

The Disbursing Office paid out over $510,000 in May. The payment of enumerators' accounts was begun on May 12, and from 1,500 to 2,000 enumerators are being paid off daily, the payments on this account reaching nearly $100,000 per day at the present time.

PLAN FOR POPULATION ANNOUNCEMENTS.

The Census Bureau expects soon to begin giving out to the press and the public the population returns for

the cities of the country. Announcements will be made from day to day, as rapidly as the totals are correctly ascertained, one announcement being made in the morning for the convenience of the evening newspapers, and another in the afternoon or evening for the morning newspapers. In order to prevent any discrimination, the announcements will be so made that all press associations and Washington correspondents can obtain the returns at the same time. Papers not having correspondents or press association service may, if they request it, be telegraphed at their own expense the population returns for their cities.

MACHINES AND LIVING CREATURES.

LIFELESS AND LIVING TRANSFORMERS OF ENERGY.

BY DR. WILHELM OSTWALD.

THE similarity between living organisms and machines has often been emphasized and utilized to explain certain structural and functional features of living beings by reference to the simpler conditions observable in machines. In the present article we will reverse the process, that is to say, we shall explain certain peculiarities of machines by reference to facts which are well known and familiar in connection with living creatures.

What, after all, is the reason why we can compare one to the other? We must secure light on this point, since otherwise the comparison will lead us into uncertainty and into a mere play with superficial analogies. The answer is this: Because both machines as well as living creatures are transformers of energy and have the purpose of carrying out the transformation of energy in the way best adapted to the particular conditions of each case.

We know that for every occurrence and for every phenomenon the question arises and can be answered: What energies disappear, and what energies are created? A steam engine consumes the chemical energy of coal and produces from it mechanical energy or work; a horse likewise consumes chemical energy, but in the shape of hay and oats, and also produces mechanical work, and that in a more efficient ratio than the steam engine. The latter, notwithstanding, is the more advantageous transformer because it is satisfied with coal, while the horse must have organic compounds of a very definite nature, since it is unable to consume coal. Man, in turn, is capable of performing mental work, and we have indeed been unable so far to construct a machine for this purpose, hence this kind of labor is qualitatively far above all machine work. But even mental work is based on transformations of energy, for without proper nutrition the mental worker also cannot accomplish anything.

Living creatures therefore are machines, in a certain sense, but they achieve a number of results which we cannot perform with machines proper, in the restricted sense of this term.

Now, there are intelligent people and stupid people, that is to say, some who are capable of performing mental work of superior quantity and quality, and others who cannot do this, and who, therefore, with an approximately equal consumption of raw energy (food) yield a much smaller output of this most precious of all forms of energy. In a like manner, there are good machines and poor ones, the difference being ultimately of the same character. A machine is the better, the more useful energy it yields from the same amount of raw energy.

As a rule, neither a living organism nor a machine is perfect at its first appearance. From the history of evolution of individuals and species, in the sense of Darwin's theory, we are familiar with the idea that a living being gradually adjusts itself to its environment and becomes more and more perfect. We know that the new species is at first very similar to the parent species, but gets transformed more and more, through a gradual atrophy and disappearance of those qualities and organs which are unsuitable for the new conditions, although for a time they continue a useless existence as so-called rudimentary organs. This is one form of adaptation. The other kind of adaptation consists in a gradual segregation of the several functions of the organism among individual organs, each of which is capable of performing its particular work better, that is to say, with a higher ratio of efficiency between energy consumed and energy produced, than the former simpler organism. The simplest form of living organism, a mere minute lump of slime with a nucleus, changes its body according to the need of the moment to act as a foot, a mouth, a hand, or a stomach. Its body, therefore, is a universal apparatus. But anybody who has been the happy possessor of a universal apparatus or combination tool, for instance, a pocket knife with which one can not only cut, but saw, drill, hammer, file, etc., will know that all these things can be done but very imperfectly with a single instrument, and that for serious and fine work it is decidedly preferable to purchase the individual tools separately. Living creatures have made the same experience, for we can observe quite generally that in the course of their evolution they tend more and more to divide their functions and to perform each function separately by means of a tool or organ ("organ" means tool) developed and adapted to carry out its particular function. The several functions are as many different means of transforming energy. An organ which is most efficient for transforming one kind of energy, will certainly not be adapted to convert any other kind of energy with a maximum of efficiency.

This theory of the origin of species is quite familiar to us as regards its application to animal life, but so far probably nobody has thought of applying it to machines. However, a mere glance at the evolution of any apparatus or process will reveal to us exactly the same peculiarities. We can readily understand, too, that this similarity must exist, for we know that in each case the problem is the same, to wit, finding the most appropriate transformation of energy, and this is solved not at one stroke, but by the slower method of progressive approximations.

For instance, when the thought was first conceived of driving a carriage or a boat by a steam engine, it was carried out by simply placing one of the stationary steam engines then known upon a carriage or boat of usual form, and combining with such engine, the customary propelling means, that is, wheels or oars, with as little change as possible. Thus, even to-day we find upon American rivers steamboats whose engines are still fitted with the old walking-beam, which at the time of the invention was a common feature of the steam engine. Otherwise, the walking-beam has practically disappeared, but in this instance it has been preserved as a rudimentary organ.

As a rule, however, such peculiar forms are not preserved. It is natural and not to be expected otherwise, that the first forms of a new combination adopt the several parts of the previously existing forms without any immediate change. The first question with such a new combination is obviously: Will it work at all; that is, will it produce an operative machine, capable of "life"? In order to answer this question, it often suffices to simply put together the previously existing parts. Only after this fundamental question has been disposed of does the further question arise, whether this form, created in close harmony with existing forms, really represents the most efficient transformation obtainable, and this question must almost invariably be answered negatively. We realize that the same thing can be accomplished in a better way and that, therefore, improvements must be made. For if we do not improve the invention, our competitors will do it and thereby kill the old form. We know that with living beings also competition is the creative reason for development.

Improvement of machinery proceeds along the two paths already indicated for living beings: First, removal of dispensable parts; second, the development of individual organs for the several functions.

The removal of the dispensable parts is simultaneous with a better adaptation to the particular conditions of the new problem. If we consider the first railroad cars, we shall perceive at the first glance that they are simply coaches placed on wheels adapted to travel on rails. Even the superfluous bulged shape of the sides (in turn descended, presumably, from the still older construction of wicker-work coach bodies) has been copied faithfully, although it is much more expensive to manufacture than straight walls, and cushions, which were very essential on account of the hard jolts on bad roads, have little justification in the smooth-rolling rail cars. It is characteristic that these rudimentary forms should disappear first in those cases where passenger accommodations are to be as cheap and as much adapted to the purpose as possible, that is to say, in the third and fourth class (the writer is referring to continental Europe). In the higher classes, where the psychic impression of comfort is sought after and paid for, cushions have been preserved to this day. Where, however, the provision of comfort is one of the chief aims, we observe the production, not of a comfortable carriage running on rails, but of an apartment rolling on the track, as in the dining cars and parlor cars of the saloon trains or limited trains.

The other phase, that is, the separation of functions and their performance by individual organs, is likewise recognized readily wherever the development of a machine can be followed through a considerable period of time. The oldest steam engine known to us, Hero's rotary aeolipile, contained all essential parts in a single element, and particularly, it was at the same time a boiler and a motor. But when the real practical development of the steam engine began, the first step consisted in separating these two elements, so that the generation of steam on one hand, and its utilization as a motive agent on the other hand, were assigned to two entirely different organs, each of which could be adapted more perfectly to its particular purpose. In the modern steam engine these two organs or elements in turn have undergone a far-reaching functional subdivision. As regards the boiler, we have a separate development of the furnace, the means for transferring heat, the collection of the steam, and even its drying and superheating. On the other hand, the enormous progress effected by separating the condenser from the working cylinder is well known to everybody who has cast but a glance at the history of the development of the steam engine. It will suffice here to allude to the separate development of such features as the admission of steam, its expansion and distribution, etc.

To examine the history of the development of technics from the point of view explained above, is not only very attractive, but instructive as well. We not only gain an understanding of what has been done in the past, but acquire a very valuable freedom in our mode of thought concerning present and future forms. For every one who has to deal with a machine or a process of any kind, will now know what questions he has to ask if seeking for improvement. He will have to look at each element and each function and first determine if it has already assumed a form adapted purely to its purpose, or if rudimentary organs have stuck to it, since such organs must be presumed to have existed originally. Secondly, for every operation performed by the machine or by the process he will have to ask: Have the functions been individualized sufficiently, or is not this function or another performed by its organ as a secondary function, as it were, that is to say, imperfectly and not with the highest efficiency?

The restricted space of an introductory article will not permit us to carry out the manifold applications of such considerations even in a single line of development in all the details which give a vivid clothing to the fundamental idea and reveal the inexhaustible variety of its manifestations. But after we have familiarized ourselves with the principles of this new theory, we shall, each of us, readily discover the same leading lines in the development of the industry with which we are best acquainted. If anybody, however, should wish to obtain a conception of the incredible variety of the individual phenomena, though they are all shown to be subject to the same principles of evolution, let him go to the German Museum of Masterpieces of Science and Technics in Munich. There he will find objects placed in the order of their development. And even if there has been no conscious attempt to arrange these objects according to the laws of evolution explained above, still it lies in the very nature of a true law that with good material it will reveal itself spontaneously.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Technissche Monatshefte.

To Cement Ivory.—Solution of isinglass, 2 parts; white gelatine, 4 parts; distilled water, 60 parts. Allow the gelatine to soften and dissolve it by heating, then concentrate it by evaporation to about 10 parts and add powdered mastic 0.2 part; 96 per cent alcohol, 1 part; oxide of zinc, 0.5 part.

RECENT PROGRESS IN AVIATION.—I.*

THE PRESENT STATE OF THE ART.

BY OCTAVE CHANUTE.

On the 20th of October, 1897, I had the honor of describing some gliding experiments that were carried on at Dune Park, near Chicago. Those experiments were made solely to study the question of equilibrium and to determine if it were reasonably safe to experiment. We had the good fortune to make about 2,000 flights (Mr. A. M. Herring, Mr. W. Avery and myself) without any accidents—not even a single sprained ankle. The only thing we had to deplore was the fact that my son, in making the flight, tore his trousers. An account of these experiments was published in the journal of this society for October, 1897, and subsequently an account was also published in the Aeronautical Annual, Boston, in 1897. That publication contained the statement that it was thought that these experiments were promising, and I gave an invitation to other experimenters to improve upon our practice. That invitation remained unaccepted until March, 1900, when Wilbur Wright wrote to me, making inquiries as to the construction of the machine, materials to be used, the best place to experiment, etc. He said that he had notions of his own that he wanted to try, and knew of no better way of spending his vacation. All that information was gladly furnished. Mr. Wright wrote me an account, subsequently, of his experiments in 1900, which gave such encouraging results that each year thereafter the brothers carried on further experiments in North Carolina and at Dayton, Ohio.

On the 18th of September, 1901, Wilbur Wright read a paper before this society, in which he gave an account of what he had done up to that time.

On the 24th of June, 1903, Mr. Wright read a second paper before this society, giving an account of his progress since 1901. Late in the year 1903 the Wrights applied a motor to their gliding machine, which by that time they had under perfect control, and they made their first flights on the 17th of December, 1903. (I might mention that I was present on each of the years during part of the experiments.) At that time Wilbur Wright expressed his intention of giving to this society the first technical paper on the subject which he furnished to any one. He said he had already promised to give a popular account in the Century Magazine, but that a technical paper, giving an account of the results and the laws which had been observed, would be reserved for this society.

In 1905 Mr. Wright told me it had dawned upon him that there was some money to be made by selling the invention to governments for war purposes, and that he would defer giving a technical paper to our society. He considered that his invention would be more valuable if, with the machine, he could give the secrets of construction and laws which have been observed. I do not know whether the paper has been written, but I hope you will get it some day.

Of the early flying experiments which had been made previous to that time I will mention but two.

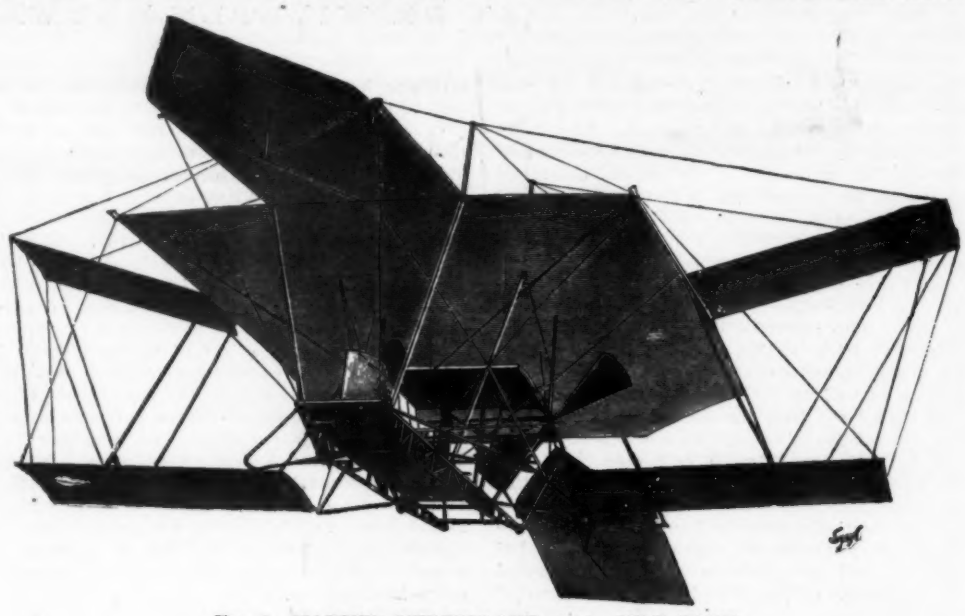


FIG. 2.—MAXIM'S MULTIPLANE, 1894. SIDE VIEW.

When run on rails at Baldwyn's Park, England, July 31, 1894, at 36 miles an hour, this machine lifted so much more than its weight that it broke a set of rails provided to hold it down and thus demolished itself.

Fig. 1 represents the Maxim machine of 1894. Mr. Maxim built an enormous apparatus, weighing 8,000 pounds and spreading 4,000 feet of surface, moved by a steam engine of 360 horse-power. That machine was run upon a track of 9 feet gage a good many times, and on one occasion it undertook a vagabond flight on its own account. Its equilibrium was bad, however, and the steam was shut off. The machine alighted

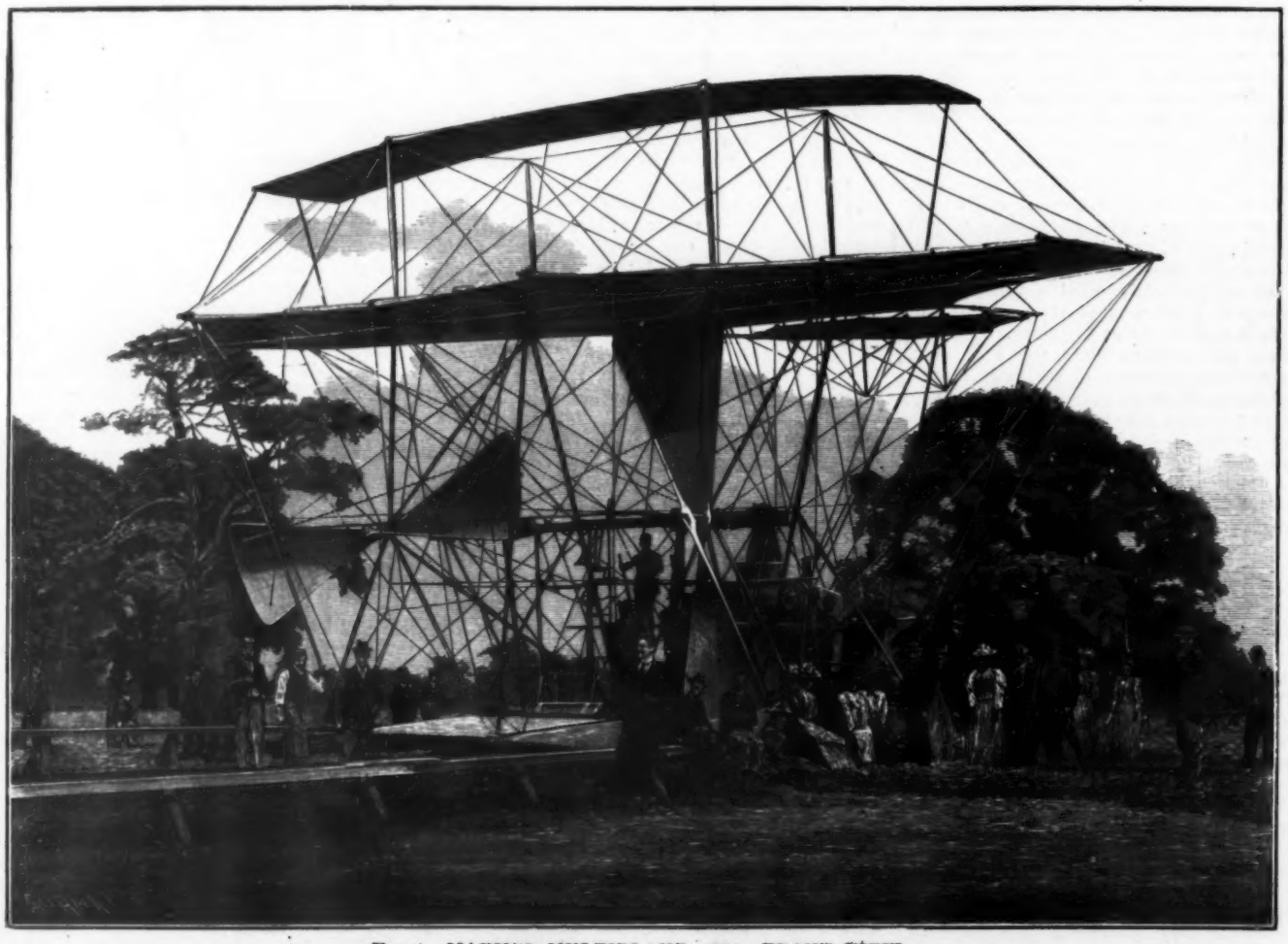


FIG. 1.—MAXIM'S MULTIPLANE, 1894. FRONT VIEW.

Weight, 8,000 pounds. Propelled by 360-horse-power steam engine. Span, 126 feet; area, 4,000 square feet; cost, $200,000.

* Paper read before the Western Society of Engineers, and here reprinted from its journal.

somewhat broken. Mr. Maxim saw clearly that it would be necessary to change the design and he has never rebuilt that machine.

Another view of the same machine is shown in Fig. 2. It had a large aeroplane at the top and two propelling screws 17 feet 10 inches in diameter, which imparted a speed of 45 miles an hour running over the track, and it was held from rising by wooden rail of 35 feet gage, which engaged outrigger wheels as soon as the machine left the sustaining track.

Maxim is now said to be building another machine, which it is expected will be completed soon.

FIG. 3.—LANGLEY'S 25-POUND TANDEM MONOPLANE, 1896.

Wings at dihedral angle. This model on May 6, 1896, flew for more than half a mile over the Potomac River, at a speed of about 20 miles an hour. Subsequently, on November 28, 1906, with a similar model weighing about 30 pounds, a three-quarter mile flight at about 30 miles an hour was achieved. The size of the heavier model was a little over 12 feet from tip to tip, with a length of about 16 feet.

FIG. 4.—WRIGHT MACHINE ON STARTING RAIL WITH STARTING DERRICK TO THE RIGHT.

The next experiments were made in 1896 by Prof. Langley. After devoting some years to experimenting, he devised a working model which he started from a launching scow. The model machine flew perfectly on the 6th of May, 1896, in the presence of Alexander Graham Bell. This machine, shown in Fig. 3, flew about three-quarters of a mile, alighted safely in the Potomac River, and was ready to fly again.

On the 28th of November, with a similar model, Langley made another successful flight, and further launches were privately made subsequently.

He was then urged by the United States government to build a full-sized machine, capable of carrying a man, and he spent three or more years in doing so. That man-carrying machine was completed in 1903, and on the 7th of October of that year the launch was attempted. The machine, however, caught a projecting pin of the launching rail and was cast down into the Potomac. The operator, Mr. Manly, was upset, carried down into the river, and came very near drowning. Another effort was made December 8th and the same mishap occurred. Part of the launching ways caught the machine, and it never entered upon flight. There is no doubt, however, that if the machine had been properly launched it would have flown. The machine is still in existence and may be launched next year or perhaps later. It was broken when alighting, and in picking it up afterward, but has been repaired. It was in North Carolina on the 17th of December, 1903, when the Wright brothers effected three successful flights, the first to alight safely in history. The longest flight covered 852 feet and occupied 59 seconds, in the face of a 20-mile wind. The weather was so inclement that they then took the machine down and abandoned experimenting for that year. There had been unfortunately some previous delays and breakages. When I went there in November to see the launching of the machine it was postponed first by the twisting off of the shaft, and then by the breaking of the propeller, which required sending it back to Dayton in order to repair the work in the shop, but full success was attained at last. In 1904 they operated in a field about eight miles from Dayton, Ohio, and it took them most of that year to learn how to turn a corner. The machine was slightly broken a number of times, repaired, and finally, in October, 1905, they got their apparatus under perfect control and succeeded in making a flight of 24 miles in 38 minutes. They made 105 flights in 1904 and 49 flights in 1905.

Fig. 4 shows the system which they have adopted in order to avoid carrying too powerful and heavy a motor. The machine is placed on a single rail, weights are hoisted on a derrick, and a rope is carried from the derrick with a return pulley to the machine. Upon the dropping of the weights the machine is given an impulse; this method being found to be preferable to the catapult which Mr. Langley had devised and which failed him on two occasions when trying to launch his machine.

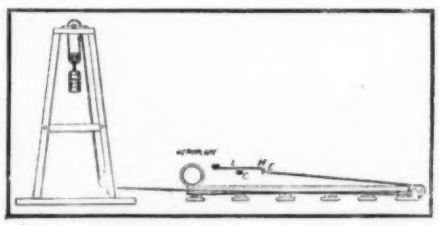


FIG. 5.—STARTING MECHANISM OF THE WRIGHT AEROPLANE.

In Fig 5 is shown the starting mechanism of the Wright aeroplane. The launching rail is 60 feet long, and with the aid of the falling weights the machine quickly acquires the necessary velocity for rising in the air.

The years 1906 and 1907 were spent by the Wright brothers in an effort to sell their machines to various governments. They had taken out patents in eight different countries, and they hoped to sell flying machines to war departments, together with the secrets, the tables of resistance, and all the elaborate calculations which they had made, but in each and every case

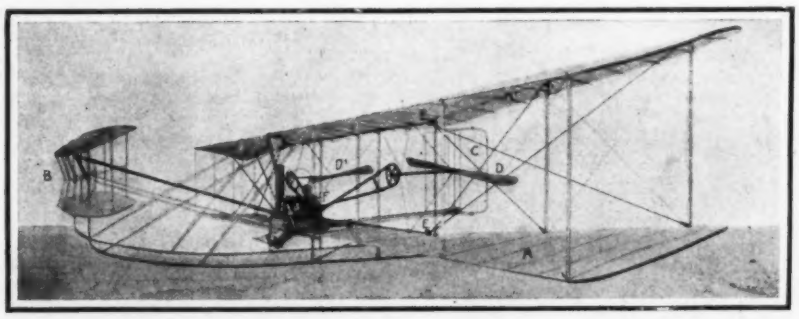


FIG. 5A.—STEERING GEAR OF THE WRIGHT MACHINE.

A and *A'*, Main planes. *B*, Horizontal rudder. *C*, Vertical rudder. *D* and *D'*, Propellers. *E*, Plane warping cable. *F*, Motor.

the government wanted to be shown the apparatus before buying. The Wrights refused to exhibit the machines until such time as they had a contract contingent upon their performing certain feats—notably, to fly with two passengers and with enough fuel to carry it 125 miles; that it must attain a speed of at least 36 miles an hour, maintained over a distance of five miles, and must fly continuously for one hour.

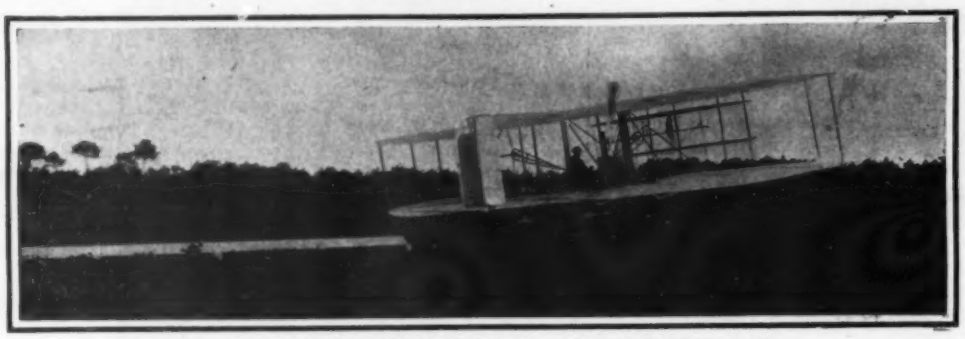


FIG. 6.—THE WRIGHT AEROPLANE LEAVING THE RAIL.

Showing the Angle of Ascent Produced by the Horizontal Rudder.

None of the governments would thus contract with them. They were offered at one time $120,000 by the French government, but they refused. They were then offered $200,000 if they would perform their feats 1,000 feet in the air. To this they said that they had no doubt that they could get up 1,000 feet, but they had never done so and would not agree to the proposition.

In 1908 they changed completely their plan of operation and decided to show their machine with the risk of its being copied and getting themselves into litigation.

In Fig. 6 is shown the machine of the 1908 design, at Le Mans, where Wilbur Wright first exhibited it to the French, while a contract had been made in this country with the United States government to furnish a similar machine. Fig. 7 represents a three-fourths front view of the machine. There is at the front a double-decked horizontal rudder. It will be noticed that these inventors have modified the make-up of a bird by putting the tail in front. Behind are placed vertical rudders, but it is the front rudder which elevates and gives horizontal direction to the machine. The rear rudder guides the machine to the right or left. Back of the main surfaces are the two screws revolving in opposite directions.

A side view of the same machine, taken at Le Mans, is shown in Fig. 6, previously mentioned. *i* designates the rear vertical rudder and *h* the horizontal rudder, operated by rods *o*, while *m* is the starting rail, *n* the rope, and *p* the skids or runners. The machine is equipped with a pair of skids for alighting, while the French people have equipped their machines with wheels. The wheels weigh more, catch more air, and are not as safe as the skids, but the skids require a rail and a starting falling weight in order to get the machine into the air, unless there is a brisk headwind.

Fig. 8 is from a remarkable photograph sent to me by Wilbur Wright, which was taken just at dusk.

Mr. Wright had extraordinarily good fortune in carrying on the experiments in France, his machine falling only once. One other accident occurred in the breaking of one of the sprocket chains in mid-air; but he then operated the machine as a glider and came down safely. The French people at first made all sorts of comments, criticisms, and caricatures of Wilbur Wright, and even published a number of amusing songs, but finally he triumphed, won their esteem and admiration, and they acknowledged that he was the master of all the aviators. Fig. 9 shows one of the flights at Le Mans. From Le Mans he went to Auvours in order to get better ground, and there made over 100 flights.

FIG. 8.—WILBUR WRIGHT FLYING AT DUSK.

FIG. 9.—WILBUR WRIGHT AT LE MANS.

The more remarkable performances which he made I have undertaken to tabulate, but I will not inflict those statistics upon you this evening. Mr. Wright established great records, however. On the 18th of December, 1908, he flew 62 miles in 1 hour and 54 minutes, this being at that time the world's record, and he beat this directly afterward, on the 31st of December, by flying 77 miles in 2 hours, 20 minutes and 23 seconds, thus winning the Michelin prize and establishing a world's record which was only beaten in the tournament at Rheims. In Rome he took up a great many passengers, and on one occasion he started without the use of starting weights, simply facing a wind of sufficient intensity and going up straight from the ground.

On the 25th of September, after returning to America, and after he had been universally acclaimed in this country, and overwhelmed (modest man that he is) with public dinners, receptions, and medals, he encircled in flight the Statue of Liberty in New York harbor, and made a magnificent flight of 21 miles from Governor's Island to Grant's tomb and return.

(To be continued.)

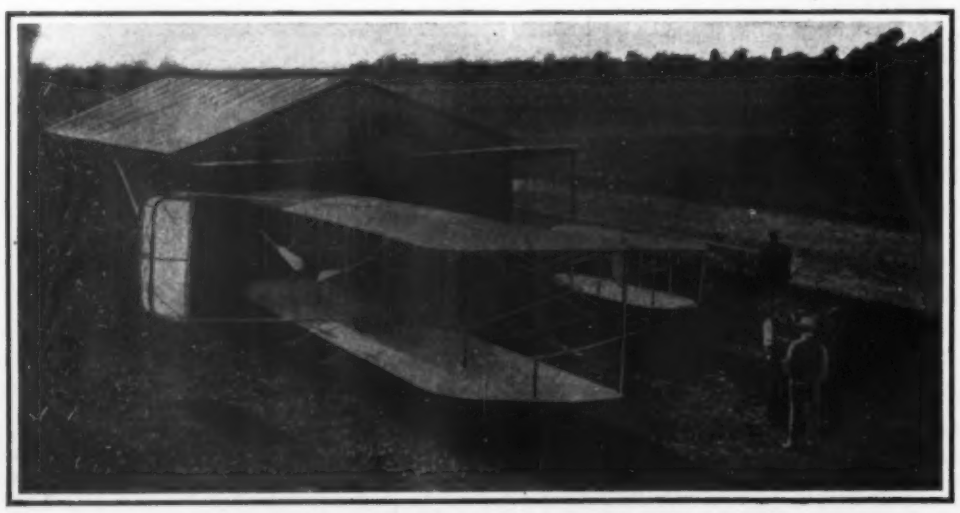


FIG. 7.—THREE-QUARTERS VIEW OF WRIGHT MACHINE.

WIRELESS IN GERMAN FISHERIES.

CONSUL-GENERAL ROBERT P. SKINNER, writing from Hamburg, describes the use of wireless telegraphy among German fishing vessels.

Three Cuxhaven steam trawlers are now equipped with apparatus, and the service is so satisfactory that efforts are being made to increase it. The most marked advantages resulting from the use of the wireless telegraph in this business are the ability of captains to advise with each other at sea as to their respective catches, and the transmission of similar reports to Cuxhaven a number of hours before the return of the ships to port. Thus vessels of the same fleet which have found poor fishing are sometimes able to join other vessels more fortunately located, in time to return with good catches. All the vessels are then able to inform the managers of the public markets respecting the quantities of fish to be placed on sale, in such manner that in the event of unusual catches arrangements can be made in advance for distributing supplies in the least possible time. The receipt and transmission of hydrographic intelligence and reporting of breakdowns in engines or other accidents of navigation are also features of importance.

NON-ALCOHOLIC BEER.

CONSUL-GENERAL JOHN L. GRIFFITHS, of London, furnishes the following information concerning a new temperance drink now being used in England:

There has been recently placed on this market a beverage which it is claimed is non-intoxicating, and still resembles and tastes like the intoxicating beer. It is brewed from malt and hops only and has no preservative in it. It does not look unlike beer, and the taste is very similar. It is made of precisely the same materials as the best English home-brewed ale, but alcohol is almost entirely eliminated, and it is stated that there is no chemical admixture of any kind. The amount of alcohol produced by the brewing process in this beverage is given as nine-tenths of one per cent, which is less than the percentage to be found in any of the ginger ales, stone beers, and other temperance beverages.

The process by which this beverage is made is the invention of a French scientist, while certain modifications were made by one of the professors of the Paris Pasteur Institute and an English brewer. Two kinds are made, ale and stout. The ale, it is claimed, has the flavor of a light beer, and the stout tastes almost exactly like a good quality of London stout.

To Repair Iron Articles.—Melt 2 parts of sulphur in an old iron vessel and add 1 part of black lead, stir well until thorough mixture has been effected and pour on an iron plate or a flat stone. After cooling, break the mass into small pieces, which should be laid over the crack in the vessel and spread out with a hot iron like solder with a soldering iron. If there is a small hole in the vessel, a copper rivet may be inserted and afterward soldered with the mass.

THE NEW YORK SKYSCRAPERS.

INTERESTING FACTS REGARDING THE ERA OF TALL BUILDINGS.

BY THADDEUS S. DAYTON.

A 16-STORY steel framework building at the corner of Wall and Nassau Streets, New York city, is being torn down to make way for one more than twice that height. It is the first of the skyscrapers to be demolished, and is the highest building that ever has been taken to pieces. Fifteen years ago it was one of the wonders of the construction of lower New York, an important point in the skyline of the city and the first big structure in what people were beginning to call the "cañon of Nassau Street."

SKYSCRAPERS ARE NO LONGER A CURIOSITY.

At the end of last year there were no less than 30 buildings of over 20 stories each on Manhattan Island alone. Thus far the two tallest are the Singer, that rises 41 stories, and, including its tower, the Metropolitan Building on Madison Square, that goes up 50 stories. Many more high buildings have been planned since then, and some are already rising skyward. At the corner of Forty-second Street and Broadway a 30-story building is going up. The new Municipal Building, near the entrance to the Brooklyn Bridge, will cover something like two full city blocks, and though it is to have but 24 stories it will tower in the air 360 feet, more than half as high again as the St. Paul, the American Surety or the Flatiron buildings.

The skyscraper era began 27 years ago, when the first steel skeleton building (the Home Insurance Company's) was erected in Chicago by W. L. B. Jenney, an architect of that city. This building differed somewhat in its principles of construction from the type that is in use to-day. The Chicago building was the first in which the system of "cage construction" was used. Cage construction means a framework of iron or steel columns and girders which carry the floors only and do not carry the outer walls. In skeleton construction the framework of iron or steel columns and girders carries not only the floors, but the outer walls also. The outer walls in cage construction had only their own weight to sustain and consequently might not have taken up much ground area if their use had been foreseen by the framers of the New York building law. Under this law the saving of ground area by the use of cage construction was comparatively small, with the result that the tallest building of this type did not exceed 13 stories. In New York, therefore, the era of skyscrapers virtually began with the Tower Building.

THE TOWER BUILDING.

This first steel framework building erected in New York still stands on lower Broadway. It is almost lost to-day among the giants that surround it, and it does not seem as though it ever could have been remarkable. In it, as well as the skyscrapers that have succeeded it, the weight of the curtain walls and floors is transmitted by girders to the wall columns at initial points and there cared for by the footings.

This Tower Building caused no end of heated discussion among architects and engineers when it was planned and while it was being put up. It was said that it could not be constructed; it was predicted that it would topple over; it was scouted as a commercial success. But it triumphantly proved all these forecasts false and by so doing inaugurated a new era of building construction and a new type of architecture that is essentially American. Here is a story that Bradford Lee Gilbert, the architect, tells of how he came to invent this building and how it received its name:

"During the spring of 1887 a client in New York, who had purchased a double plot on New Street—just south of Exchange Place—with a Broadway frontage (two-thirds the length) of only 21 feet 6 inches, with the understanding that the adjoining property on Broadway could be purchased later to square the plot, found this impossible and himself incumbered with a non-income property, difficult to dispose of except at a considerable loss.

"In this dilemma my client appealed to me most urgently to find some possible solution of this problem which would allow him to retain and improve this property upon a paying basis. The building laws were explicit as to the required thickness of walls for superstructure, and anything higher than the existing buildings on the plot could only be erected at an actual loss, as it would not pay to erect a high building on the narrow Broadway plot to reach the larger rear building, when the thickness of walls required would leave a passageway only on the three main Broadway floors of a little over 10 feet in width; while a low entrance building on Broadway for a higher office building on New Street would only benefit abutting property. The problem grew perplexing and proportionately interesting."

Studying over the seeming impossibilities, Mr. Gilbert discovered two or three very interesting things. One of these was that the building law of New York did not limit the height of the foundations either below or above the curb line. Suddenly the idea occurred to him that it would be possible and thoroughly practicable to carry up the foundations seven or eight stories—or even to the roof itself—in this way obtaining floor space and additional width where it was most valuable, thus starting the superstructure eight stories above the curb, or practically omitting it altogether.

SKELETON CONSTRUCTION AND THE BUILDING LAW.

Though strikingly new and revolutionary from an architectural and a construction point of view, there seemed nothing in the building law to conflict with this theory. With his plans carefully worked out, Mr. Gilbert went to Superintendent D'Oench, then of the Building Department, and discussed the matter in detail. Superintendent D'Oench agreed to the feasibility of the proposition, but stated frankly that, while it did not conflict with existing building laws, no law existed under which this construction could be approved. The plans therefore went to the Board of Examiners of the Building Department, with personal explanations, and were finally approved April 17, 1888. Of them in detail Mr. Gilbert said:

"The construction throughout the narrow portion of the building, as filed and erected, called for 12-inch curtain or non-bearing inclosing walls between the foundation columns below the eighth story, and in some sections the entire height of the building, thirteen stories, or about 160 feet; the weight of the curtain walls and floors being transmitted by girders to the wall columns at initial points, and there cared for by the cement and pile footings. Therefore, out of a total available width of 21 feet 6 inches, 20 feet clear space was obtained (on account of an existing party wall on the south) through the most valuable and rentable of the Broadway floors and offices. In fact, this wall space, saved and rentable over the usual and previous construction, was estimated as worth upward of $10,000 annually."

It is interesting to note that 10 years later, during 1898, in "A History of Real Estate Building and Architecture," written by William J. Fryer, who was a member of the Board of Examiners of the Building Department when the plans for the Tower Building were filed and approved, Mr. Gilbert was conceded to be the inventor of the skyscraper constructions. On the Tower Building to-day there still remains the bronze tablet, placed there eleven years ago, reading as follows:

"This tablet, placed in 1899 by the Society of Architectural Iron Manufacturers of New York, commemorates the erection during 1888-9 in this, the Tower Building, of the earliest example of the skeleton construction in which the entire weight of the walls and floors is borne and transmitted to the foundations by a framework of metallic posts and beams, originated and designed by Bradford Lee Gilbert, architect."

Mr. Gilbert and the owner had some idea of getting the new principle of skeleton construction patented, but possible infringements and lawsuits, it was thought, would outweigh the probable advantages. What the public and the architectural profession generally thought of the new building Mr. Gilbert tells interestingly:

HOW FEARS OF STABILITY WERE OVERCOME.

"After the plans were filed and the contract awarded, much interest being excited by the curious spectacle of a building 21½ feet in width rising to a height of 160 feet above its footings at 50 Broadway, many prophecies and comments were necessarily forthcoming. The owner, somewhat nervous, called one day with a letter from a prominent engineer who stated his belief that 'the construction would prove dangerous if not disastrous during a heavy blow.' I confessed it did look as if a great blank wall so high and narrow would blow over, but it was hardly to be supposed that, even if I were willing to assume the personal and professional risk, the Building Department would permit me to erect a menace to life and adjoining property.

"'What would happen to me,' the owner explained, 'if it should blow over? Think of the damages resulting! It would ruin me!'

"'Well, how about me?' I replied. 'Probably a noose would remove me from all further worry.'

"Taking out my drawings and strain sheets of the wind-bracing from footings to roof—practically a Howe truss on end—I continued:

"'If you kindly follow me, I will demonstrate to you by graphical analysis that the harder the wind blows the safer the building will be, as over 100 tons, under hurricane pressure, while the wind is blowing 70 miles an hour, is transmitted and cared for by the footings, and during the actual moment of inertia your building is safest.'

"He looked at me more confused than ever, and answered, 'I cannot follow you and know nothing about strain sheets.'

"'I did not believe you did when I started,' I replied, 'but as you must trust somebody, unless you know of some good reason otherwise you had better trust your architect for your peace of mind's sake.' Then I added, 'To show my faith in the building and its construction, I will move my offices over and occupy the two upper floors on the Broadway end, and if the building falls I will fall with it.'

"That seemed to satisfy him. Just after this conference, one Sunday morning I awoke to find the wind blowing at a regular hurricane. As the building was in its most dangerous condition, the walls partly up and openings uncovered, affording the wind full sweep, I hurried downtown, and emerged from the elevated station on Broadway; there stood the building! The watchman helped me, and after climbing to the top we dropped a plumb line to the basement, and not even vibration was perceptible. I returned up Broadway singing the Doxology."

By a somewhat curious coincidence 1889, the year of the completion of the Tower Building, was also the year in which the first commercially successful electric elevator was designed. The elevator has been as important in the development of the modern skyscraper as skeleton construction. The two mechanical principles were first combined in the same structure a year or so later in the Waldorf-Astoria Hotel. The estimate is that to-day the elevators in the buildings of New York carry each 24 hours close to 7,000,000 passengers, or almost twice as many as the combined traction companies—surface, elevated and subway. Modern elevator service is said to be at its best to-day when on each trip, on the average, stops are made at four-tenths of the landings and each car carries four-tenths of its maximum load.—The Iron Age.

In the Electrotechnische Zeitschrift, L. Bloch summarizes the conclusions of the Photometrical Committee of the Verband Deutscher Elektrotechniker regarding the best methods of attaining uniformity in methods of specifying illumination in interiors and exteriors. The object of their deliberations was to agree on a method which should be acceptable to gas and electrical engineers and also applicable alike both to measurements in open spaces and interiors. The recommendations of the committee will, it is suggested, be adopted tentatively for one year after the annual meeting of the Verband, and meantime have been submitted to the Verein von Gas- und Wasserfachmännern for consideration from the standpoint of the gas industry.

The committee recommended that measurements should be made in a horizontal plane. In making this suggestion they are guided largely by the recognition of the difficulties involved in the actual measurement and calculation of vertical illumination in the streets, and by the fact that in most interiors it is mainly the illumination of horizontal surfaces, tables, etc., in which we are interested. Libraries and picture galleries, of course, present special problems, and require special treatment. They advise, further, that measurements should be made at a height of 1 meter above the ground in all cases, and that the mean, maximum, and minimum illumination should be specified. In comparing the illumination in different interiors, etc., the expression "lux per square meter of floor area" is to be employed. The consumption of electric lamps is to be expressed in watts and that of gas lamps in liters of gas per hour.

MAKING SAPPHIRES IN THE LABORATORY.

THE PROCESS OF MANUFACTURE AND PROPERTIES OF SYNTHETIC SAPPHIRES.

BY A. A. HELLER.

THE making of synthetic or reconstructed rubies on a large scale dates from 1903, when Prof. Verneuil published his famous process of fusing chromated alumina in the oxyhydrogen furnace. A number of plants sprang up since all over France, and the industry developed so that to-day a conservative estimate places the total product at seven million carats per annum.

The ruby once assured, chemists turned their attention to the next gem in the corundum family—the sapphire. The question was to find a substance which would color alumina blue. The problem looks so simple, and yet it took many years to solve it. The fact of the matter is, that no one knew with certainty what it was that gave the sapphire its beautiful blue color. Was it chromium, as some claimed, but in a state of oxidation inferior to that of the ruby; was it ferric oxid combined with some other metal in such minute quantity that its presence could not be traced? Mineralogists were not agreed on this point.

In practical experimenting, the addition of ferric oxid to alumina gave no results whatever. It was then decided to try cobalt, a substance known for its powerful blue coloring tendency. Again it did not work; cobalt would not combine with alumina, its melting point being much lower. One of the experimenters, M. Picard, had a brilliant idea—he thought of adding to the alumina a substance which would reduce its resistance to the flame and thus permit the cobalt to combine with it. The binding agent was found in sulphate of magnesia. About 8 per cent of this, ½ per cent of cobalt and 91½ per cent of alumina, fused in the oxyhydrogen furnace, produced the first blue boule. A small fraction of chrome-oxid was added to the combination to change the piercing blueness of the cobalt color; and in this manner the first "Hope Sapphires" were realized, early in 1907. About a year later, another chemist, M. Louis Paris, published a note on these sapphires, claiming for them a place next to the ruby. In England, however, Prof. Smith, of the British Museum, declared them to be sapphire spinels, since, like the spinel, they contained magnesia. Because of this the stone was about ½ point softer than the natural sapphire; had no dichroism, and showed a violet tinge under artificial light. The latter defect was gotten rid of, however, in subsequent specimens.

Since 1907 these sapphire experiments were conducted at two plants in Paris, by M. Paris at the works of Disclyn & Cie. at Boulogne; and by Prof. Verneuil at the laboratories of the Societé Hellerite (an American company), at Boulevard de la Chapelle, Paris. Here M. Verneuil was assisted by a young American chemist, Mr. I. H. Levin, a pupil of Prof. Morgan of Columbia.

Of course the Hope Sapphire, while quite satisfactory commercially, and approaching nature's gem very closely—an asymtomatic sapphire, Prof. Verneuil called it—was yet not the ideal stone, since it was not truly synthetic. Experiments were therefore steadily

M. A. VERNEUIL.
Professeur au Conservatoire des Arts et Metiers, Paris.

continued. Now in working on the magnesia sapphire, it appeared that a slight quantity of titanium added to the general formula, gave the stone a much prettier blue. Titanium was then an active colorant—a fact which was already known through the use of this oxid in several other industries.

Here then was a valuable point; yet in the furnace titanium did not behave as expected—it gave everything but the desired color. The work seemed almost hopeless; but nothing daunted, Verneuil aided by Levin commenced a new series of experiments which necessitated at the same time a thorough study of the nature of the flame, and the influence of the furnace on the process of oxidation of the ingredients employed, and they came to the conclusion that ferric oxid must be brought in again. A combination of alumina, titanium and ferric oxid, prepared with the minutest care, was placed in the furnace on the tenth of January, 1910, and after several hours of careful watching, a white hot boule was taken out, which on cooling assumed the magnificent blue color of the finest sapphire.

We can do no better than quote from Prof. Verneuil's report to the Academy of Sciences on the scientific side of this discovery: "It is admitted, since the results obtained by Sainte-Claire Deville and Caron in the reproduction of corundum, that the oriental sapphire owes its beautiful blue color to the presence of a small quantity of oxid of chromium at a degree of oxidation inferior to that of the sesquioxid.

"The simultaneous production in several of their experiments of red and blue crystals has led these scientists to conclude, in a rather hesitating manner, however, that the difference which exists between the coloration of the ruby and that of the sapphire is due to the proportions of the oxid of chromium, or probably to the state of oxidation of this chromium. Yet in synthetic reproduction this oxid of chromium, employed in conjunction with various reducing agents did not realize the blue color, in spite of all efforts. On the other hand, in experiments where peroxid of iron replaced the sesquioxid of chromium in a reducing atmosphere, crystals of dark blue color were obtained showing black under artificial light. This dark blue, obtained by means of an inferior oxid of iron, seems to correspond with the blue of a variety of sapphires found in certain parts of Australia.

"But if we introduce a small quantity of titanic acid in combination with the oxid of iron, this acid may be reduced to the state of titanium oxid, and remain in this state long enough to permit the fusion of the materials in the furnace, to allow a thorough refining and develop the beautiful blue color, identical with that of the sapphire.

"This sapphire of fusion, of which several specimens are submitted herewith to the Academy, and the making of which still presents great difficulties, contains 98 per cent of alumina and 2 per cent of ferric oxid and titanium.

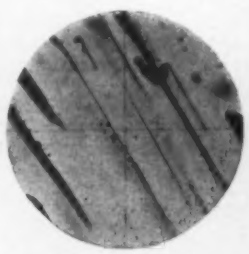
"M. Wyrouboff, who was kind enough to examine these 'boules' from the crystallographic point of view, found them to possess the same properties as the synthetic rubies, which he examined before. They take the form of a single crystal which is uniaxial, optically negative and little birefractive; consequently having all the optical properties of the natural sapphire. Furthermore, their composition and crystalline construction must evidently lead to the conclusion that these stones are in every other respect also identical with the natural.

"That sapphire is colored by titanium oxid was already demonstrated by Ginti in his experiments with beauxite in the electric furnace; the similar result obtained in the oxyhydrogen furnace is thus as much in accordance with the established facts as the previous assertion that the coloring is due to the inferior oxid of chromium.

M. A. VERNEUIL AT THE WORKS OF THE SOCIETE HELLERITE.

THE WORKS OF THE SOCIETE HELLERITE IN PARIS.

1. Parting Figures.



2. "Flow Lines," Internal.

3. Round and Pear-shaped Cavities and "Flow Lines."

4. Band of Cavities Under Three Facets.

5. "Rifts" or Breaks Near an Edge.

6. "Rifts" or Breaks in Body of Stone.

"Hence in the present state of our knowledge of this subject it seems to me reasonable to admit side by side with the chromium colored sapphire, according to the opinion of Deville and Caron, a sapphire colored by the oxides of iron and titanium."

Prof. Verneuil made his report to the Academy on January 17th. News of the discovery was sent immediately all over the world, and aroused interest and comment everywhere. In America the first specimens of the new sapphire were recently received by L. Heller & Son, the American correspondents of the Societé Hellerite of Paris. Several stones in the rough and cut were submitted to Prof. Alfred J. Moses of Columbia University for examination, and the conclusions to his report are as follows:

The chemical analysis shows the material submitted to be nearly pure alumina (Al_2O_3) with, however, a measurable quantity of titanic oxide. The crystallographic and optical tests show that the material submitted is crystallized and that the cone by all tests is one homogeneous, faceless (anhedral) crystal.

The crystalline, optical and other characters determined are closely those of natural sapphire. In the absence of natural faces or cleavages the crystalline system, as determined by the optical tests, may be either hexagonal or tetragonal. The parting figures, however, shown in Photo 1 point to the hexagonal system. Any two natural substances which were as nearly identical in chemical and crystallographic characters as the specimens submitted and natural sapphires would be called identical. The difference is one of origin.

Thus all the beautiful minerals of the corundum group, the ruby, the sapphire, the white sapphire, the pink sapphire, etc., can be made to-day in man's workshop, as well as in nature's. The world is richer through this discovery; for what has been reserved until now for the enjoyment of a few has been placed at the disposal of the many.

HOW TO TEST SEED CORN IN SCHOOL.*

SOME SIMPLE SUGGESTIONS.

BY A. C. TRUE.

THERE are at least three reasons why teachers, especially in the rural districts, should be interested in seed-corn testing as a school exercise: (1) It furnishes an easy and interesting study in seed germination and plant growth, (2) the extended use of a good method has vast economic value in improving the productiveness of American agriculture, and (3) the teaching of it in the rural school exerts a strong influence toward increasing the confidence of parents in the permanent worth of good school work. The teacher whose work is supported by such a sentiment in the community has her powers of usefulness increased many-fold in comparison with one who is indifferent to the home interests of her pupils and their parents. The teacher who once begins intelligently to try some simple exercises in agricultural nature study will not be long left in doubt as to the responsive interest which she can awaken in any kind of productive school work. Children love to do things—especially things that are obviously useful; they need only judicious direction in order to turn this instinct into various forms of continuous self-education—which is the only kind that "sticks."

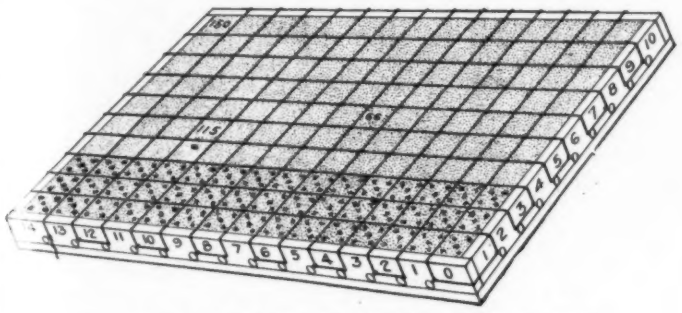


FIG. 1.—A SAND TRAY FOR TESTING SEED CORN.

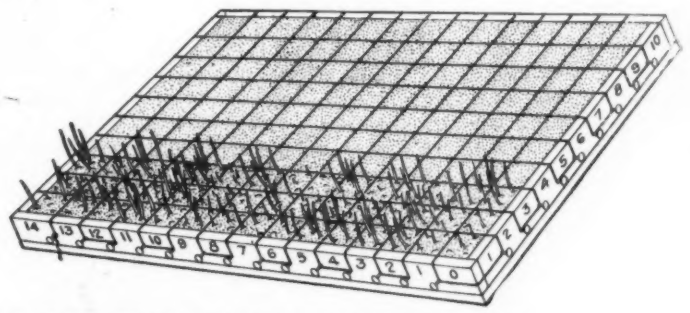


FIG. 3.—SAND TRAY, SHOWING CORN SEVEN DAYS AFTER PLANTING.

It has come to be true that almost every farmer and rural school-boy now understands the importance of testing seed corn before planting—and testing it in the ear rather than after shelling. But many farmers fail to do as well as they know in this matter, because they regard many of the methods that have been recommended for testing seed corn as "too much trouble." The plan that is here described is simple enough to be easily followed by any boy or girl in the public schools,† and it costs very little.

The only materials needed are a shallow wooden tray, a small handful of carpet tacks, a few yards of wrapping twine, sand enough to fill the tray, and three or four quarts of water. The tray (or several of them) can easily be sawed from an empty soap or cracker box. When finished, it should be about 1½ inches deep inside, 15 inches wide, and 23 inches long; but any of these dimensions may be varied slightly. This tray is divided into small squares by a checkerboard lacing of twine across the top. It is convenient to have these squares about 1½ inches on a side, ten of them in a row across the narrow way of the tray, and fifteen the other way.

Fig. 1 shows the general appearance of such a tray and the method of lacing the twine back and forth across the tray and under the tacks. This lacing with the string should not be done until the tray has been loosely filled with dry sand heaped up a little above its top edge. Then the sand should be scraped off with a yard-stick, or other straightedge, even with the top of the tray. After lacing with the string the tray is then ready for planting.

Have the children arrange the ears to be tested in rows of ten, to correspond with the rows of squares

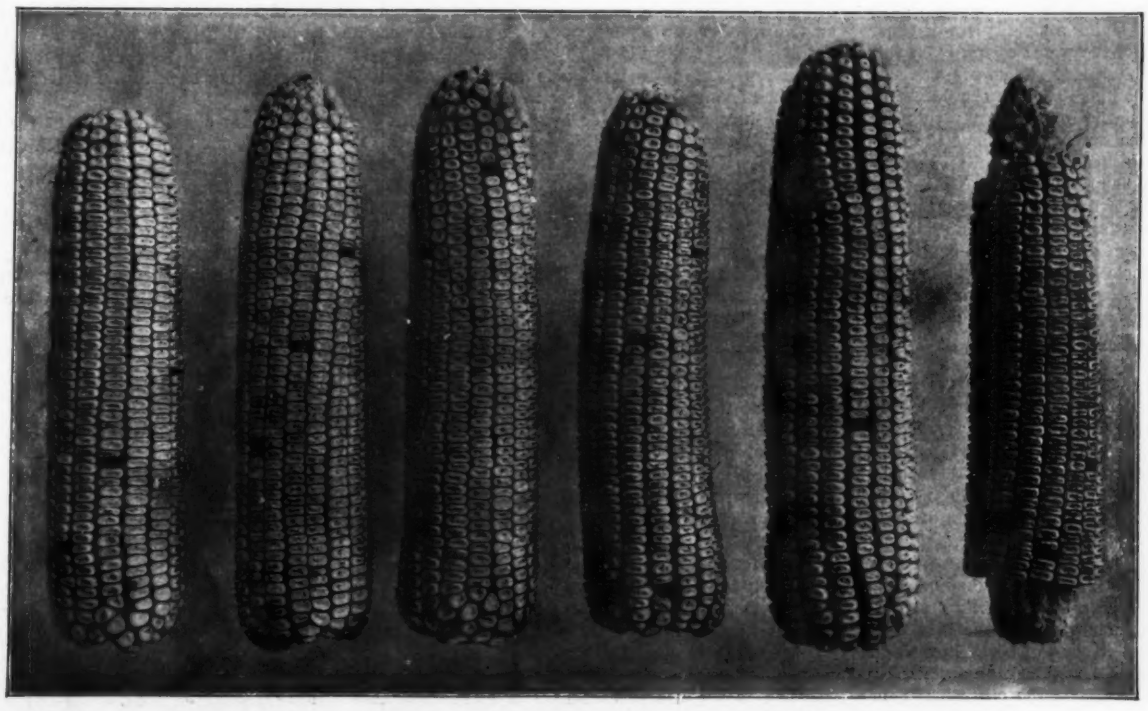


FIG. 2.—EARS OF SEED CORN WITH KERNELS REMOVED FOR TESTING.

* Circular prepared in the Agricultural Education Service of this office by Mr. F. W. Howe, assistant in agricultural education, for the U. S. Department of Agriculture.

† So far as can be learned, the essentials of this plan were first developed by Prof. J. A. Jeffery, of the Michigan Agricultural College.

across the tray. These rows of ears should be kept in a dry, warm place on the floor, on corn racks, or on shelves, where it can be certain that they will not be disturbed or displaced until the test is completed. A nail is sometimes driven into the shelf or floor at each end of a row of ten ears to keep them in place.

When ready to begin the test, two children can work to the best advantage, one to handle the individual ears and the other to plant the tray. The first takes up ear No. 1 in the first row, and, with the point of a pocket-knife applied to the edge of a kernel, removes five kernels from each ear, passes them to the second pupil, and carefully replaces the ear in its row. The kernels should be taken in succession (taking only those of average size) from about an inch above the base of the ear to the same distance below its tip, passing spirally around and lengthwise of the ear. This insures a fair test of the whole ear, as it sometimes happens that one side or one end of an ear is sound while the other will not grow. Fig. 2 shows a few ears with kernels removed in this spiral fashion.

The second pupil plants each five kernels in the square which corresponds with the ear from which they were taken. Each of the first four kernels is set in one corner of the square, point downward, and pushed down just far enough to be covered by the dry sand when the forefinger is withdrawn. The fifth kernel is planted in the center of the square, and all should have a uniform depth below the surface of the sand. Fig. 1 shows the first three squares planted in each of the fifteen rows.

Two pupils working together can plant at least one square a minute, and much faster with a little practice. But it is important to do the work carefully and treat all the kernels alike, so that the test may be scientifically exact. This is why dry sand, or some other earth of uniform quality and free from foreign substances, is recommended for filling the tray. The test, and the conditions are artificial only to the extent of treating all kernels alike, which is necessary to secure reliable results. Testing in soil is much the most natural method of determining the probabilities of growth in the field.

Figs. 3 and 4 show the progressive growth of corn plants in the tray at the end of successive periods. It is best to make the final examination of the plants at some point between the stages shown in these two views, as the latter is a little too far advanced to permit doing the work easily. The plants should be about 2 or 3 inches high. Begin at square No. 1 and carefully examine each square in regular order through to the last. If you find five good, sturdy plants growing from the five kernels planted in a square, the ear from which they came is all right for planting in the field. It is not necessary to pull these plants up or examine the roots; you can be sure that the roots are all right if the plants are satisfactory.

If there are five plants in the square, but two or more of them are shorter than most of the others in the tray, or look pale and sickly, take at once the ear from which they came out of its row and do not let it get mixed with those that are to be shelled for planting in the field.

If there are four good plants in the square, but the fifth one is smaller or can not be seen at all, dig down carefully until you find whether the kernel germinated. Sometimes the plumule (young stalk) is held at the tip by the tough skin or hull of the kernel until it is bent over and starts to grow horizontally or downward under the sand. Such a stalk may not yet have its head out in the air when the tray is examined, and so may be pale and weak from lack of breath and sunlight. That would not show any positive fault in the ear from which it came and would not be a sufficient cause for discarding the ear.

If one kernel out of the five has not begun to grow at all, while the rest from the same ear are an inch or two above the sand, it will not be safe to plant that ear. Do not save any ear for seed after the test unless you feel sure that every kernel planted in the field is likely to grow. Every poor ear planted spoils about one-fifteenth part of an acre in the cornfield—and yet some farmers would "blame it on" the crows, or the weather, or something else which they could not help; but they could be sure of planting seed that they know has shown itself able to grow. Occasionally some farmers still make the mistake of first shelling all their seed corn (or buying shelled corn for seed) and then testing a hundred kernels of it. If there is one bad ear in the lot that was shelled, its kernels are then mixed with all the rest, and there is no way to discover or remove them. The ear holds them all together until it can be determined whether they will grow.

Until the test is finished, it is very important to keep the ears in place, so that the one corresponding to any square in the tray can be picked out at once.

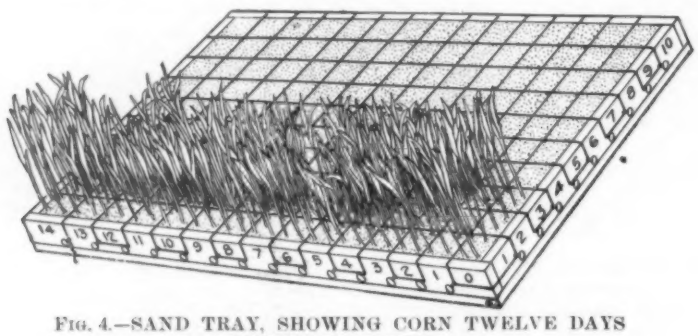


FIG. 4.—SAND TRAY, SHOWING CORN TWELVE DAYS AFTER PLANTING.

same sand should not be used twice unless baked and carefully sifted before the second planting.

When a tray has been planted it must be thoroughly watered and kept in a warm room (perhaps on the warming oven of the kitchen range at home or on a shelf above the schoolroom stove), where it will not be upset or disturbed until the test is finished. The watering is best done by laying a small piece of paper flat on a tray and pouring the water carefully on this until the sand is fully saturated. (There is a reason for using the paper.) The planted tray should not be allowed to dry out until the young corn plants are an inch or two above the sand. Sometimes the corn roots are stiff enough to push the kernels up out of the sand. When this happens they should be covered again by sprinkling some damp sand on them.

This method of germinating seed corn has been carefully tested for a long term of years. It is one of the best plans to use in schools because the necessary materials can be easily procured, the germinating seed does not need to be uncovered or disturbed during the

If the ears are not laid out in rows of ten, they must be numbered in some other way. The number of any square is easily known by referring to the way the tray is numbered in Fig. 1. Thus square 66 is the sixth square in the row numbered 6; and the number of any square in the tray is determined by this simple rule: Consider the number marked at the left end of any row as tens, and add to this the unit number representing the given square (shown in Fig. 1 at the right-hand end of the tray). Note whether squares 115 and 150 are correctly numbered according to this rule. If the corresponding ears are arranged in fifteen rows (calling the first row zero), the number of any ear can be found in the same way. If this plan is not followed, each ear should be tagged and numbered in consecutive order. Fifteen ears of good size will plant an acre of corn, three kernels to the hill.

(It is a good "practical" and "cultural" problem in arithmetic to figure out the number of hills in an acre—say 3 feet and 8 inches apart—the number of kernels required to plant them, and then count the kernels on an ear of average size grown in your own school district. How many acres can be planted with the seed corn tested in one tray?)

Good care must be taken of the seed corn after it is tested, and the testing would better not be done more than two or three weeks before planting in the field. Through lack of care a lot of good seed corn can be spoiled in three weeks—or even three days—by wetting and molding or by freezing. Before shelling the tested ears it is considered best to remove the small or irregular kernels for upward of an inch from each end of the ear (note the last ear in Fig. 2), as these kernels do not usually germinate and grow at the same rate as those in the middle of the ear, and their irregular size also prevents uniform dropping in the planter. All the remaining kernels on the tested ears can then be shelled together, and it is best to mix them thoroughly afterward, unless you wish to select a few of the best unshelled ears to start a "breeding plat." But that is "another story," told in a number of bulletins published by the Department of Agriculture and the State experiment stations. These will be sent if requested personally. It is a good experiment to try.

The corn-testing method here described can be easily carried out in the ordinary schoolroom if the temperature is not allowed to go below 40 deg. F. If there should be any danger of freezing, the planted tray can be taken to a near-by pupil's home, kept there until the plants are large enough for final examination, and then brought back to the school carefully covered with a blanket that will not crush the young stalks. It is well to have at least one tray tested by the school so that all the children can see and understand the entire process. Then as many as can, should be encouraged to test at home the corn which their fathers expect to plant. Where this can not be done at home, some schools have offered to do the testing for farmers; but this requires that the ears to be tested shall be carefully numbered, or arranged in rows of ten, and that five kernels from each shall be brought to the school in little envelopes or packets numbered to correspond with the ears. When the test is finished, the numbers of the poor ears must be carefully recorded for reporting back to the farmer from whom the seed came.

It makes a good experiment for the school garden to plant some of the ears which showed poorly in the school's testing tray, and see whether they will do any better under outdoor conditions. In contrast to this, some of the best ears can be planted in a school "breeding plat," as suggested in a preceding paragraph. When the teacher understands how this should be done, the school may become the means of greatly improving the quality and yield of corn throughout the whole district.

TYPE-CLEANING PREPARATIONS.

THE cleansing of the letters or type is regarded, in printing offices, as an exceedingly troublesome and expensive operation, and the proprietors are for that reason, interested in reducing the outlay for this purpose to the smallest possible proportions. The natural consequence of this is that for the production of these cleansing preparations only the cheapest possible raw materials can be considered.

In order to obtain an idea in regard to the materials available for this purpose, we must first inform ourselves in regard to the composition of the inks used for printing. For the better class of books linseed oil varnish, rubbed down with lamp-black or some other suitable body color, is used. On the other hand, for newspapers and other cheap printing, body colors, rubbed down with different kinds of varnish find employment. These varnishes consist in varying quantities of linseed oil varnish, raw linseed oil, rosin oil, rosin, soap, thick turpentine, mineral oil, etc.

If, as the varnish for printing inks, only linseed oil varnish, or this mixed with other saponifiable oils, the cheapest and quickest-working cleansing medium would be a caustic soda lye, which would saponify or emulsify the oil, setting free the color, which would be separated as a dirty deposit. Its employment however is open to the objection that it corrosively attacks the hands of those working with it, and by careless splashing may result in serious injury to the eyes. Nor does it clean the type used in printing with inks mixed with mineral oils very well, the soap solution formed by the combination of the lye with the saponifiable portion of the varnish, not being strong enough to dissolve the carbohydrates. In addition, no actual saponification of the fatty oils takes place, only their emulsification.

To obviate the caustic effects of soda lye recourse was had to the use of carbonate of soda. But this in itself possesses no very marked cleansing properties, so that to obtain a better effect some soap was added to it and thus originated the existing type cleaning powders which are almost the same as the cheap soap powders of commerce.

The production of these soap powders is effected in various ways. Either the soda is stirred into a mixture of soap waste and water or with oil and lye, a soap paste is made, into which the soda is crutched. According to the latter method, we can make a type cleaning powder according to the following directions:

In an iron kettle heat 200 parts of soda lye of 25 deg. Bé. to boiling and add to it 200 parts of oleine. When the mass is saponified crutch in 200 parts of ammonia soda and 80 parts of water and shovel the mass on to a stone floor where it is allowed to cool. Then it is broken into pieces and these are ground to powder in a mill.

A portion of the carbonate of soda has at times been replaced with powdered caustic soda, but this is not to be recommended as the caustic soda when kept in the air, as is mostly the case, is transformed into carbonate of soda.

Much better is the addition of a fat dissolving substance, like turpentine, etc., but only a small quantity of it can be incorporated with the powder.

In some printing offices strong alkaline paste soaps are used, which also have an excellent cleansing effect, and on account of the cheapness with which they can be produced, are, to a certain extent, advantageous to the proprietor.

The cleansing of type can of course be effected only with the aid of a fluid in which the oils used will dissolve. But, on account of their cost, only easily inflammable solvents, for instance benzine, can be considered; and working with them is not only not unattended with danger, but on account of the unavoidable evaporation and consequent loss, likewise too expensive.

An effective cleansing medium for type that would meet all requirements might, without doubt, be prepared in the form of a strongly alcoholic soap solution, to which a considerable quantity of solvent has been added. We have in view the so-called water-soluble oils, in which for this purpose mineral oil may be replaced with a solvent; for instance, benzine of high boiling point, petroleum of low boiling point, pine oil, etc. Even better of course where the price admits are the non-combustible solvents, tetrachloride of carbon, mono or dichloride of benzol, tetrachloride of ethane, etc.

All these solvents are of course only emulsified in the soap solutions. If we desire to have these solvents clearly soluble in water, in which form they are much more effective than if merely emulsified, we can use for this purpose a neutral turkey-red oil. One hundred parts of turkey-red oil dissolve about 25 parts of chloride of benzol, tetrachloride of carbon, etc., of which solution we can add as much as price will allow to the alkaline soap solution.—Translated from Der Chemisch Technische Fabrikant.

SODIUM SILICATE AND CONCRETE.*

THE EFFECT OF ONE ON THE OTHER.

BY ALBERT MOYER, ASSOC. AM. SOC. C. E.

THE easy abrasion, or what is commonly called "dusting," of cement concrete floors in office buildings, has called my attention to the need of a material which could be readily and economically applied, resulting in the hardening of the concrete itself and not producing a veneer which would soon wear off under foot or other traffic.

Nearly all of the so-called floor finishes which are designed to protect the floor from dusting prove to be merely oil paints, some of them simply Portland cement ground up in varnish or linseed oil with some coloring matter and possibly other harmless materials which would enable the inventor to obtain a patent.

There did not seem to be any material on the market which would sink into the pores and itself harden so as to form an actual wearing surface and not a veneer. This, with the possible exception of a chemical formula often used in France and Germany to protect plaster and prepare same for mural decoration. This material is hydrofluosilicide of magnesium and zinc. The objection to its use for the protection of concrete floors or the hardening of concrete surfaces for any purpose whatever is entirely from the standpoint of economy, it costing from eight to ten cents per square foot to correct the bad workmanship which is so often the cause of the dusting of concrete floors.

I therefore started some experiments with sodium silicate, both in powdered form and in the form of water glass. I found that the powdered sodium silicate, which can be obtained commercially, contained impurities which did not render it readily soluble in water. The sodium silicate in the form of water glass of about 40 deg. Baume was readily mixed with water, the object being to thin the sodium silicate down to a point where it would penetrate as deeply as possible into the pores of the concrete, making several applications until the pores were all filled and the sodium silicate flushed with the surface. That which flushed with the surface, being soluble, was readily washed off with water, and that which remained in the pores, having come in contact with the lime and other alkalies, hardened into what we may be pleased to term "mineral glue." From experiments extending over several months I found that we had obtained the results we had been striving for.

This suggested various other uses, all of which had the object in view of hardening and waterproofing the surface of concrete; such as the protection of arrises, caste stone, waterproofing hollow concrete blocks, hardening, waterproofing, and protecting interior surfaces of cisterns, and protecting buttermilk vats against the action of lactic acid; the protection of porous concrete surfaces against the action of oils, preventing efflorescence, seeping out of soluble salts from Portland cement mortar, concrete, or stone, and the possible prevention of hair cracks and crazing.

It is also entirely within the range of possibility that such treatment of interior and exterior surfaces of concrete may be of valuable assistance in solving the drain tile, alkali and sea water problem. After the tile has been made and set hard for two or three weeks, and has then dried out so as to permit the introduction of sodium silicate in thin solution into the pores, the drain tile may be immersed into a bath of sodium silicate composed of 1 part water glass, 40 deg. Baume, and 3 parts water, a total of 4 parts. The immersion to be a sufficient length of time to allow the tile to absorb the maximum quantity. It is then removed from the bath and allowed to dry. Thus the sodium silicate coming in contact with the lime and other alkali present in the concrete forms into a mineral glue which is insoluble and very hard.

I believe I have suggested a sufficient number of uses to illustrate the possibilities of sodium silicate applied to concrete.

The action of sodium silicate applied to dry concrete is vastly different from that which is mixed with the cement while the concrete is being gaged. Through the courtesy of Mr. S. Warren Hartwell, Mr. W. R. Dunn, and some opinions, advice, and suggestions from Dr. Allerton S. Cushman, we carried on some experiments with cement and sand briquettes which were mixed with a thin solution of sodium silicate and water, compared with normal briquettes treated in the usual way, and also compared with normal briquettes afterward immersed in water containing 10 per cent of sodium silicate.

I also made up some briquettes of 1 part hydrated lime, 3 parts standard sand, and water; also briquettes of 1 part hydrated lime, 2 parts building sand mixed with a solution of 1 part water glass, 2 parts water; the initial set was a one-half hour, final set one hour. As soon as dry, they were immersed in a solution of sodium silicate, 1 part water glass, 40 deg. Baume, 3 parts water. After the briquettes had absorbed the maximum amount of this solution, they were allowed to dry out. They had become hard, but showed very little strength in tension. They were then immersed in water for several days, no disintegration taking place. The object of this test was to ascertain the solubility of lime briquettes so treated.

A series of briquettes were made of 1 part Portland cement, 3 parts Ottawa sand, mixed with the usual quantity of water containing 10 per cent of sodium silicate. The results show a falling off in strength compared with the same sample of cement mixed with the usual quantity of water, no sodium silicate added, and the briquettes immersed in water in the usual way. This falling off was noticed both in the 7 and 28-day periods.

Briquettes of 1 part cement, 3 parts Ottawa sand, mixed with the usual percentage of water containing no sodium silicate, after 24 hours were immersed in water containing 10 per cent of sodium silicate, with the result that the strength was increased, as compared with the same sample of cement treated in the usual way, no sodium silicate having been added in mixing the cement with the water.

No neat cement tests were made, for the reason that the comparisons we wished to obtain were those which would tend to show that the introduction of sodium silicate into concrete after final set would strengthen such concrete. Reducing the results to figures, I give below the average results of a full set of experiments:

One part Portland cement, 3 parts Ottawa sand, briquettes mixed with the usual amount of water and immersed in water:

Seven days—285 pounds per square inch cross section.

Twenty-eight days—347 pounds per square inch cross section.

Mixed with water containing 10 per cent sodium silicate and immersed in water:

Seven days—117 pounds.

Twenty-eight days—203 pounds.

You will note a considerable falling off in strength.

Mixed with the usual amount of water containing no sodium silicate and after 24 hours immersed in water containing 10 per cent of sodium silicate:

Seven days—360 pounds.

Twenty-eight days—497 pounds.

Quite a considerable increase in strength.

We assume that the sodium silicate coming in contact with the lime or other alkalies and alkaline earth salts gives a reaction which causes a deposit of silicic acid, which forms into an insoluble gelantinous silica and hardens into and acts as a mineral glue.

Sodium silicate mixed with the cement while the mortar is being gaged quickens the setting time, an arbitrary period determined by the stiffness of the mortar to a degree which will bear a wire or needle under certain pressure. The final hardening, however, never attains as great strength as normal slow-setting concrete.

I mixed up some water glass in proportion of 1 part water glass, 3 parts lime water; that is, water containing all the lime which it would take up in solution, then decanted off. On standing for a few minutes it became a jelly. I then mixed up a solution of sodium silicate and ordinary water, mixed with it neat cement to wet consistency, probably 30 per cent water. Within a few minutes this mass had become a stiff jelly; this jelly is very quickly formed, thus quickening the time of setting, which in reality is merely a period of definite stiffness, and has little or no relation to the time of maximum hardening. This jelly having been formed before the cement had time to harden, interfered with the process, and weakness resulted, which is shown by the tests.

I would suggest that those interested in this subject experiment by using a retarder, such as a 10 per cent solution of sodium hydrate caustic or a similar solution of magnesium sulphate. If the formation of the gelatinous silica is retarded until the cement has had an opportunity to set, it is possible that the strength of laboratory specimens will be increased. We might thus obtain some information as to the effect of sodium silicate on concrete if experiments are made extending over long time periods. A set of specimens in the form of briquettes and cubes for tensile and crushing strength may be made and stored in water, breaking these specimens in regular periods of time up to two years. As far as I know, this has not been done, and might possibly lead to some interesting data on this subject.

Concrete is strengthened and hardened when sodium silicate in solution is applied to the surface. The concrete has hardened normally, and that which is porous will allow the introduction of sodium silicate to some little depth in the pores, the depth depending upon the porosity of the concrete. The action of forming into a jelly thus takes place without interfering with the process of hardening, and this gelatinous substance forms into an insoluble mineral glue.

Without experimental proof, and based upon the theory of maximum density, it is my opinion that this method or treatment by the application of sodium silicate to concrete surfaces will act as waterproofing and prevent the action of salt, alkaline, or sulphurous water on the surface.

This is a field which requires quite some laboratory experiments, which should be followed up by field experiments. Sodium silicate in the form of water glass is very cheap, less than one cent per pound, and a pound thinned down with water to the proper consistency that will enter the pores of the concrete, will cover quite an area. I treated the floors of the office in which I am located, covering some 1,400 square feet at a cost of $0.003 (three mills) per square feet, which includes all labor and material.

Should exhaustive experiments and field tests demonstrate by long-time results that there is no further action of water on surfaces so treated, and that the sodium silicate remains in the form of an insoluble mineral glue, many very serious problems will have been solved, such as the action of alkalies or sulphurous soil on drain tile and other concrete products, the action of sea water on concrete, waterproofing tanks, the protection of tanks against certain acids and oils, and the dusting of concrete floors.

* Read before the American Society for Testing Materials.

The announcement that it is now possible to produce ductile metallic tungsten in the electric furnace means much for the tungsten lamp which has heretofore been hampered by its filament fragility. Under the present methods of manufacture, tungsten particles have been welded into a continuous filament by passing an electric current through a binding material containing the metallic particles and driven off by the high heat. By this new method the metallic tungsten can be drawn into fine wire much stronger and more rugged than the sintered filament. It is expected that the incandescent lamp made with these new filaments will not only have a longer life, but also be even more efficient than the present tungsten lamps.

SCIENCE NOTES.

Assuming, as stated by Mme. Curie, that small quantities of silicon have little effect on the magnetic properties of steel, W. Brown finds that the magnetic moment per gramme increases smoothly with increase of chromium to a maximum at 2.5 per cent of chromium, whence it falls until 3.5 per cent of chromium is reached; further additions leaving the magnetic moment unaffected. The maximum points are, however, liable to disturbance through varying quantities of carbon, silicon, manganese, tungsten and copper; and these substances affect also the retentiveness of the magnets. The magnetic moment per gramme also varies with the form of the sample tested, as shown by the results of various observers.

Why do we permit the annual exportation of more than a million tons of our best phosphate rock, for which we receive at the mines the paltry sum of five million dollars, carrying away from the United States an amount of the only element of plant food we shall ever need to buy, that, if retained in this country and applied to our own soils, would be worth not five million, but a thousand million dollars, for the production of food for the oncoming generation of Americans? Why this exportation? Because the present owners of American land learned only the art of agriculture and were never taught the science of farming; and it may well be repeated that the responsibility rests not with the farmer, but with the statesman and the educator.

Why has the southern Aryan civilization developed but one school for every five villages, while the northern Aryan, save in Russia, opens to every child the door of the school which leads on, for those who will, to the college and university? Because only a prosperous nation can afford the trained intelligence for education of its people. Education in America is not the cause, but the product, of our prosperity; and, thus far, the prosperity of this nation is due to our conquest of the former inhabitants and to the consequent acquisition of the great natural resources of this country, including, primarily, vast areas of rich virgin soil; and, secondarily, immense supplies of timber, coal, and iron. American prosperity has done more than educate Americans; it has educated western Europe, first of all by relieving the overcrowded condition of those impoverished lands, and subsequently by making large direct contributions to European prosperity, in supplying cheap food and fertilizer and a good market for European products, manufactured in large part from the low-priced raw materials secured from this and other new countries.

That vast areas of land that were once cultivated with profit in the original thirteen States are now agriculturally abandoned is common knowledge; that much of the land in all adjoining States is in the process of abandonment is known to many; and that the common lands in the great agricultural regions in central United States are even now in process of the most rapid soil depletion ever witnessed is known to all who possess the facts. Already the question of food has begun to exert pressure in this country. Already the masses, the common people, the "ninety per cent" must consider a reduction in their standard of living. Poverty is even now making such demands upon the revenues of the state that education and research already suffer from inadequate support; and the only hope of the future lies in the application of science and education to the control of industry and to the control of population; and let us never forget that agriculture is the basis of all industry, and that the fertility of the soil is the absolute support of every form of agriculture.

It has been suggested by various workers that the sun's velocity with respect to the ether could be deduced from the observed times of the eclipses of Jupiter's satellites. The problem assumes increased importance at the present time because of Kapteyn's discovery of the two principal star-drifts, and the material necessary for the computation will soon be available following the discussion by R. A. Sampson, of the Harvard photometric observations of the eclipses of the satellites. The method of analysis is indicated, taking into account the three causes of error, (*a*) irregularity of Jupiter's surface, (*b*) uncertainty of actual epoch of eclipses, (*c*) error of observation of time o mid eclipse. As the residual effects it is hoped to detect depend on the direction of the line drawn from the earth to Jupiter, and will have in consequence a period of about twelve years, it is important for the present investigation that the Jovian system should be free from any influence having an approximately equal period. This matter has been inquired into, and it appears that no disturbing influence of this nature is to be anticipated. To arrive at some idea of the probable errors a hypothetical orbit is discussed, from which it appears that it is important to choose the coordinate axes with care, so as to avoid the component with largest probable error having too great an influence on the result.

ENGINEERING NOTES.

In a report recently issued by the Transvaal Mines Department, F. W. Harboard deals with the possibility of the remunerative manufacture of iron and steel in the Transvaal. There are large deposits of magnetic quartzites near Pretoria, which could be mined at a moderate cost, and similar deposits at Airlie, which could be mined at a low cost. The deposits have not yet been extensively proved as to quantity and average quality, but outcrop samples have shown 46 per cent of iron and 24 per cent of silica. Smaller quantities of richer non-silicious ores occur in other localities. The chief difficulties standing in the way of the manufacture of pig-iron are satisfactory supplies of good limestone and metallurgical coke at a reasonable cost. If the South African railways would agree to take 30,000—35,000 tons of rails and sleepers per annum, then an iron and steel works, including one large and one smaller rolling mill, and with a capacity of 1,000 tons of steel per week, might be established on a sound basis, but it would be impossible to produce steel at a price low enough for export, or to compete effectively against imported products in the neighborhood of the seaports, unless under an ample protective tariff. Mr. Hibbard also considers that there is no possibility, at present, of the remunerative production of pig iron in the electric furnace in the Transvaal. An electric steel plant designed for the treatment of the large accumulations of scrap at the railway yards at Pretoria and elsewhere, would, however, in his opinion be successful both technically and financially, and he suggests that the best method would be for the government to concede to private individuals the exclusive right to purchase the accumulated railway scrap and the future annual production for a fixed number of years at a reasonable price.

A special type of track construction has been developed for use in the tunnel which the New York Central lines are building under the Detroit River. Certain modifications of the original designs were made. The tunnel in which the track is being laid has a total length of 8,360 feet, of which 2,625 feet is twin-tube subaqueous section under the river. Each of the two tracks is in a separate tube, and the two tubes form a monolithic concrete structure. To provide for the concrete filler between the ties of the track, to be laid later, 1-inch round dowel pins 7 inches long were embedded 6 inches in the base or invert concrete while it was fresh. The ties are short, extending under one rail only. One end of each piece abuts against a concrete shoulder cast in the invert, and the other end is cut to the slope of the sides of the trench in the invert and along the center line of the track. Every fifth tie on one side of the track is made 1.5-foot longer than the balance to provide a support for the underrunning third rail, through which current will be transmitted to the electric locomotives to be used in handling traffic through the tunnel. Untreated long-leaf yellow pine timber is used. Immediately before each tie is placed, a ¼-inch coat of cement grout is spread on the surface on which the piece is to rest. The timber then is worked slightly from side to side and tamped until its upper surface is at the same elevation it would have reached if the grout had been omitted. In this manner the voids in the surface of the concrete are filled completely, and the timber is bonded to it. Then the space between the ties is filled with 1:2:4 concrete up to the line of the slope of 1 inch in 3 inches on the surface of the shoulder against which the inner end of the pieces abut. The surface of this concrete also is depressed ½ inch on the center line of the space between the ties. The sloping surface of the concrete between the ties quickly conveys to a central trench what little water does reach the interior of the tube. The track has 100-lb. rails of A. S. C. E. section; these are laid with plain 25-inch 4-bolt angle-bars of a special section to admit of heavy electric bond wires between the bars and the rails. Spreading of the rails is prevented effectually by the shoulder against which the pieces of the ties abut. The dowel pin in each timber, and the concrete in which the latter is embedded are believed to be ample to prevent any inward movement that might be caused by unusual conditions.

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TRADE NOTES AND FORMULÆ.

To Make Yellow Ivory White.—Allow it to lie in water acidulated with sulphuric acid for 2 to 4 hours.

To Bleach Ivory.—Lay it in a glass dish filled with turpentine and expose it, for 3 to 4 days, to the sunlight.

Phosphorescent Enamel.—Mix 15 parts of luminous color, 10 parts of fluor spar or cryolite powder and 3 parts borate of calcium, rub the whole down with water, apply it to porcelain, glass, etc., and burn it in the ordinary manner.

To Polish Ivory.—Smooth it with sandpaper, rub down defective spots, then rub off with soft flannel and washed chalk. The chalk can be moistened with water or oil. Finally, complete the polish with a piece of soft linen, on which a little oil has been dropped.

Rouge or Polished Red (according to Vogel).—Bring a solution of green vitrol to a boil, add to it a solution of oxalic acid, as long as a precipitate is obtained, wash and dry the latter and heat it to something over 360 deg. F. This will transform it into an exceedingly delicate red powder, which is much prized as a painters color and is used also as a polishing medium for optical glasses.

Black Stains for Ivory.—(*a*.) Tie 1 part of logwood extract in little linen bags and boil in 10 parts of water for 2 hours. Add to the fluid 0.1 part of crystallized soda, allow to boil up, stir and skim off the scum. Lay the ivory in it for 2 to 3 hours, then transfer it to a solution of 1 part of bichromate of potash in 15 parts of water. (*b*). Lay the ivory for a time in solution of nitrate of silver crystals, then expose it to the daylight.

Table Vinegar for Preserving Purposes.—To improve the flavor of table vinegar, especially to impart to it an agreeable bouquet, to 10,000 parts of preferably not too sharp vinegar, add 10 parts cloves, 10 parts pimento, 10 parts ginger, 10 parts coriander and 20 parts mustard seed, all coarsely crushed, also a sliced lemon. The mixture is allowed to stand in a closed bottle for 10 to 12 days in a moderately warm place and should then be filtered to impart brilliancy to the vinegar.

To Color Ivory with Tar Colors.—In order to free them from fat, the objects are first placed for two hours in benzine, then rinsed and treated for 10 minutes in a mixture of 10 parts of hydrochloric acid and 1,000 parts of water, rinsed and placed in the dye solution. The solutions should be at a temperature of 122 deg. to 140 deg. F., and the objects should be left in them until they have acquired the desired depth of color, then washed off, dried and finished by polishing. The dye baths to be used are for red: Fuchsine or eosine, 5 parts in 1,000 parts of water, 2 parts tartaric acid. Orange: Methyl orange, 8 parts in 1,000 parts of water with 200 parts of vinegar. Yellow: Naphthol yellow, 5 parts in 1,000 parts of water, with 200 parts of vinegar. Blue: Methyl blue, 5 parts in 1,000 parts water, 100 parts vinegar. Green: Brilliant green, 5 parts in 1,000 parts of water, 100 parts of vinegar. Brown: Vesuvine, 8 parts in 1,000 parts of water, 100 parts of vinegar. Violet: Methylviolet, 8 parts in 1,000 parts of water, 100 parts vinegar. Black: Nigrosine, soluble in water, 10 parts in 1,000 parts of water, 100 parts of vinegar.

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